

**Consumption decisions in the food sector –
Conceptual and empirical studies from the food marketing context**

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List of abbreviations and symbols

| | <i>English</i> | <i>German</i> |
|-----------------------|--|--|
| AGOF e.V. | Working Group for Online Media Research e.V. | Arbeitsgemeinschaft Onlineforschung e.V. |
| BMBF | Federal Ministry of Education and Research | Bundesministerium für Bildung und Forschung |
| BMEL | Federal Ministry of Food and Agriculture | Bundesministerium für Ernährung und Landwirtschaft |
| BMWi | Federal Ministry for Economic Affairs and Energy | Bundesministerium für Wirtschaft und Energie |
| BVE | Federation of German Food and Drink Industry e.V. | Bundesvereinigung der Deutschen Ernährungsindustrie e.V. |
| COSUS | Consumers in a Sustainable Food Supply Chain | Konsumenten in einer nachhaltigen Lebensmittelwertschöpfungskette |
| DEDIPAC | Determinants of Diet and Physical Activity | Determinanten des Ernährungs- und Bewegungsverhaltens |
| EHI | EHI Retail Institute GmbH | EHI Retail Institute GmbH |
| ERR-42 | Economic Research Report Number 42 | Wirtschafts-Forschungsbericht Nummer 42 |
| EU | European Union | Europäische Union |
| EU-28 | Refers to the 28 member states of the European Union (status 2017) | Bezieht sich auf die 28 Mitgliedsstaaten der Europäischen Union (Stand 2017) |
| GfK | Society for Consumer Research | Gesellschaft für Konsumforschung |
| IAT | Implicit association test | Impliziter Assoziationstest |
| IF | Impact Factor | Impact-Faktor |
| IfD Allensbach | Allensbach Institute for Public Opinion Research | Institut für Demoskopie Allensbach |
| IVV | Fraunhofer Institute for Process Engineering and Packaging | Fraunhofer-Institut für Verfahrenstechnik und Verpackung |
| PwC | PricewaterhouseCoopers GmbH Wirtschaftsprüfungsgesellschaft | PricewaterhouseCoopers GmbH Wirtschaftsprüfungsgesellschaft |
| R&D | Research and Development | Forschung und Entwicklung |
| USA | United States of America | Vereinigte Staaten von Amerika |
| VHB | German Academic Association for Business Research e.V. | Verband der Hochschullehrer für Betriebswirtschaft e.V. |

List of abbreviations and symbols (continued)

| | <i>English</i> | <i>German</i> |
|------------|---|--|
| WZW | Technical University of Munich, School of Life Sciences Weihenstephan | Technische Universität München, Wis- senschaftszentrum Weihen-stephan |
| → | Please refer to | Siehe |

1 Introduction

1.1 Guiding principles of the dissertation

From a bird's-eye view, a decisive factor of today's scholarly work is the permanent effort to conduct **interdisciplinary research**¹. Given the fact that consumer behavior, particularly within the food context, is such complex stresses the need of gaining knowledge while considering aspects of both neighboring and distant scientific disciplines. From a worm's-eye view, within the marketing discipline, the effectiveness of marketing communication depends on the characteristics of a single product or service. Besides following an interdisciplinary approach, it is a great benefit considering a range of **intradisciplinary areas**.

Seen from a **practical perspective**, FoodDrinkEurope, the umbrella organization of the European food industry, addresses **health** and **sustainability** as two of the main challenges for today's society (FoodDrinkEurope 2017). A study of PwC (2014) also identified health and sustainability as trends and key topics in the food sector in the upcoming years for both, consumers and companies. It will be of increasing importance to provide information to consumers to make suitable choices for a balanced diet and healthy lifestyle, and to look into ways to recommend how to reduce household food waste as a part of sustainable behavior. Given the fact that when food is wasted at the end of the chain, all the resources invested in a product's lifecycle are lost. These challenges need to be addressed by R&D activities resulting in food innovations. A third leading driver of food innovations in Europe is to give pleasure to consumers, including the variety of human senses, underpinning the role of **sensory** aspects in new product development processes (FoodDrinkEurope 2016).

Following the principles of inter- and intradisciplinary research, the dissertation at hand is situated at the intersection of various subtopics of marketing, namely sensory marketing, health marketing, and sustainability marketing. Moreover, it takes aspects of neighboring (e.g., psychology) and distant disciplines (e.g., food science) into account (Figure 1). In accordance with Krishna et al. (2017), in this dissertation **sensory marketing** refers to marketing that intends to shape a multi-sensory experience for the consumer affecting their perception, judgment, and behaviors, both at the time of purchase and consumption. **Health marketing** aims at developing, pricing, distributing, and promoting healthy products and services, and/or enhancing healthy behaviors of consumers (Mai et al. 2012). Established marketing tools and methods are applied and paired with approaches from health psychology (i.e., rea-

¹ 'Interdisciplinary research' refers to the integration of knowledge and methods from different research domains and requires the collaboration of researchers from diverse backgrounds to solve problems whose solutions are beyond the scope of a single domain (Porter et al. 2006). As most studies have been conducted with co-authors from food science, psychology, or medicine, this dissertation might be considered as an interdisciplinary work.

sons of and attitudes towards healthy behavior) and health economics (i.e., government regulations on the health market). The third subtopic, **sustainability marketing**, addresses the development of marketing strategies in the light of economic, ecological, and social challenges (Belz and Schmidt-Riediger 2010). Sustainability marketing, as understood in this dissertation, aims at analyzing consumer perceptions and behaviors in the context of food products helping to develop solutions for sustainable food choices and promote these solutions effectively to selected target groups. More precisely, sustainable food choice refers to choosing suboptimal foods resulting in avoiding food waste at a consumer level. The last couple of years, food waste is considered to be one of the sustainability issues that need to be addressed (Aschemann-Witzel et al. 2015).

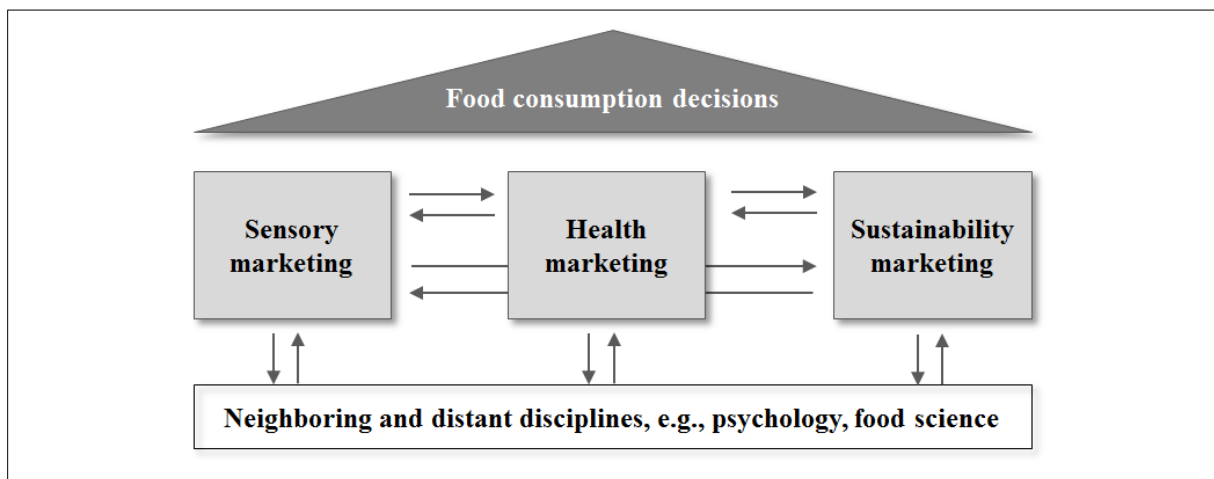


Figure 1: Related topics of the dissertation project (source: own illustration)

This dissertation is structured as follows: First, the dissertation takes a **broader view** by introducing the reader to the economic relevance of the food sector and the complexity of food marketing. Second, it focuses on the **distinct subtopics** and specific research questions providing the reader with the synopsis of the conceptual and empirical articles included in this cumulative dissertation. Third, the conclusion section will propose implications for managerial practice and presents avenues for future scholarly research.

1.2 Illustrating the food sector's economic relevance

From a **German perspective**, the food and drink industry continues to have great economic importance. With over 580,000 employees in 5,940 companies the German food and drink industry – mainly characterized by small and medium sized enterprises – is one of the biggest industries in Germany (BVE 2017b). In 2016, the German food and drink industry

generated a total turnover of 172 billion Euros, thereof 115 billion Euros on the domestic market and 57 billion Euros on foreign markets (BMW_i 2017). Germany is the third largest exporting nation for foods and drinks on the global market with an export ratio of 33%. Accordingly, every third Euro in the food sector is earned abroad. Within the EU, particularly prominent markets are the Netherlands, France, and Italy. Outside the EU the most important markets are Switzerland, USA, Russia, and China (BMW_i 2017). With a share of 9.4% of the total turnover in the manufacturing sector the German food and drink industry achieved the fourth place within the top-selling sectors following the automotive industry, engineering, and chemical industry (Statistisches Bundesamt 2016). Business cycles, seasonal fluctuations, volatile commodity prices, and impacts of political regulation or crises cause short-termed ups and downs of the business climate in the food and drink industry. However, in the long run the food industry represents a continuously stable and resistant economic sector (BVE 2017a). In sum, being one of the largest and innovative economic sectors, the food industry is a key driver for welfare, growth, and employment in Germany (IVV, WZW 2010).

From the **European perspective**, a similar picture can be observed. The European food and drink industry is the largest manufacturing sector in terms of turnover, value added, and employment in the EU (FoodDrinkEurope 2016). In 2014, it generated a total turnover of 1,089 billion Euros (15.6% of the turnover in the EU manufacturing industry), contributed 1.8% to the EU-28 gross value added², and employed 4.25 million people (15% of the employment in the EU manufacturing industry) in 289,000 companies (FoodDrinkEurope 2016). EU food and drink exports nearly doubled over the past decade to reach 98 billion Euros in 2015 and a trade surplus of 25 billion Euros. More than one quarter of EU food and drink exports are sold to non-EU countries, such as USA, China, and Switzerland.

On an **international level**, the food and drink industry faces massive economic, social, and environmental challenges. If the current trend of a growing world population continues, the demand of food for human consumption will increase by at least 60% until 2050 (FoodDrinkEurope 2016). Simultaneously, natural resources upon which food production relies are becoming scarce, and food and energy production compete as corn and sugar are increasingly important for both (McKinsey 2015). In a nutshell, these facts underpin the importance of the German, European, and global food and drink industry as a vital pillar of modern economy.

² In 2013, the value added resulted in 212 billion Euros. This equals 13% of the value added in the EU manufacturing industry. The gross value added is the value of goods and services produced by a sector minus the cost of the raw materials and other inputs used to produce them (FoodDrinkEurope 2016).

1.3 Making marketing in the realm of food tangible

Due to the impressive economic importance of the food sector, the discipline of marketing has become an integral part of the strategic and day-to-day business of food producers and retailers. Marketers are often torn between satisfying the needs of consumers, the demands of shareholders, and the concerns of public health organizations (Chandon and Wansink 2012). **Food marketing** refers to the identification and creation of “[...] foods that deliver [...] benefits [for the consumers]; to communicate these benefits; to profitably package, price, and distribute these foods, and to protect these innovations by branding the food so that it acquires unique and positive associations in the mind of consumers” (Chandon and Wansink 2012, p. 587). The subsequent list outlines some peculiarities and current challenges for the food sector and how food marketing can contribute to address these challenges:

- Expenditures on foods and drinks vary from 8% to 30% across EU member states households (BVE 2017a). Compared to the other EU member states, in Germany, only 10% of total private consumption fell upon food and non-alcoholic beverages (EU average: 14%), whereby it should be noted that the average available income of German private households is comparatively high (BVE 2017a). Thus, companies of the food sector vigorously compete for and struggle to increase or redistribute **consumer spending**.
- Food is a consumer good that is purchased repeatedly, but consumers’ views and attitudes can change quickly. In general, what the consumer wants is tasty, inexpensive, varied, convenient, and healthy food (probably in an individual order of property importance) (Chandon and Wansink 2012). Understanding, influencing, and meeting these, partly conflicting, **consumer demands** as well as monitoring progress in these areas are key functions of food marketing and the development of competitive strategies (Martinez 2007).
- The change in **consumption patterns** due to the demographic development with an increasing share of elderlies, the digitization of society, and the increasing health and environmental awareness (BVE 2017a) require new or improved food products and services as well as customized communication contents and modern methods of communication.
- Extensive purchase decisions are characterized by elaborated information acquisition and a high involvement of the consumers (e.g., purchasing a car). Contrairily, in **habitual purchase decisions**, like for food, involvement in the decision making is low, consumers have formed habits in choosing a product, and keep on buying it without

looking for alternative brands or stores (Hoffmann and Akbar 2016). A great amount of food marketing is needed to change consumers' purchase habits.

- **Sensory perception** in terms of haptics, olfaction, audition, taste, and vision plays a great role in the consumption of food (Krishna 2012). Moreover, food is purchased and consumed repeatedly and in short intervals leading to a strong memory effect that needs to be considered in food marketing activities (Collins and Stafford 2015).
- As consumers are faced with a **variety of foods** to choose from, they often use only rules of thumb in their food decision making which allow satisfactory choices with minimum effort (Scheibehenne et al. 2007). Thus, food marketers need to develop effective marketing strategies to stand out from competitors.
- Food is one of the most **highly branded** goods (due to mostly packaged products), which lends itself to an ideal advertising platform (Story and French 2004).

Food marketers have created a myriad of ways to influence consumers' food choices. Marketing communication – including advertisement, package design, labels, claims, and brands – is one type of marketing activity (Chandon and Wansink 2012). The high practical relevance of food marketing manifests itself in the following exemplary **facts and figures** from the food sector:

- In 2015, the German food and drink industry spent a total of 2,405 million Euros on **advertising**, of which 84% was spent on television, 7% on internet and mobile, 6% on magazines and newspaper, and 3% on radio (AGOF e.V. 2016).
- Although television advertising is still the most popular communication channel, its importance is declining. The amount of **online buyers** of food and beverages increased from 1.95 million in 2013 to 3.34 million (rise of 71.3%) in 2016 (IfD Allensbach 2016).
- **Food retailing** is the most important distribution channel for the food and drink industry – followed by the food service sector and exports (BVE 2017a). Contrarily to food producers, printed advertising accounts for about 56% of the total gross advertising expenses, online advertising for about 12%, and in-store promotions for about 10% (EHI 2015).
- Spending for chocolate and sweets reach a share of almost 40% of the total advertising budget, ranking third within television advertising (Hamburger Abendblatt 2012; Heffler and Möbus 2014) – by that token the food industry is often accused of **promoting obesity** (Chandon and Wansink 2012; Seiders and Petty 2004).

- Due to the high number of **failed product launches** in the food retail sector of about 52% (sweets) to 66% (dairy), food marketers from both food industry and retail are continually challenged to attract consumers' attention and to foster purchases (GfK 2015).

To draw an intermediate conclusion, research on consumption decisions in the food sector is motivated by a growing economic relevance of the food sector including food marketing activities (→ chapters 1.2 and 1.3), an ongoing societal responsibility and the continuation of scientific preliminary works considering current topics, for instance with regard to health and sustainability issues (→ chapter 1.1).

2 Dissertation project

2.1 Objectives

As previous research about consumption decisions in the food sector is diverse and fragmented (Grunert et al. 2016; Jacobsen et al. 2014), the objectives of this cumulative dissertation are threefold. First, it highlights consumption decisions in the food sector as an interdisciplinary field by **portraying prior research activities** in terms of relevant predictors of food choice, scientific domains, and the amount of research over time (→ chapter 3.1). Second, the dissertation **elaborates on various subtopics of food marketing** by summarizing prior research activities on extrinsic and intrinsic food product attributes in consumer and sensory science (→ chapter 3.2), by putting emphasis on product packaging as an extrinsic product attribute considering different person- and product-related boundary conditions (→ chapter 3.3), by investigating food product's visual appearance and the impact of communication messages (→ chapter 3.4), and by highlighting the impact of food product's visual appearance on overall sensory experience (→ chapter 3.5). Thus, the articles of this dissertation generate **new knowledge** at the intersection of sensory marketing, health marketing, and sustainability marketing. By integrating these three research streams, new avenues for future research open up (→ chapter 4.2) and new directives for managerial practice in the food sector are gained (→ chapter 4.3). As a consequence, by impacting both, practice and research, this dissertation aims at achieving the third, most superordinate goal to advance the **societal and managerial understanding of consumers as decision makers** within the food context so that future food marketing activities can be designed to benefit both, consumers and food industry management.

2.2 Overview of included articles

As a cumulative dissertation, contributions of this work have been disseminated in academia via peer-reviewed journals and academic conferences. In total, five articles are included within this cumulative dissertation. The articles were generated during two international projects for whose realization the doctoral candidate was responsible. In the project „DEDIPAC – Determinants of Diet and Physical Activity” (BMBF, term: 2014-2017), the doctoral candidate analyzed factors of food that influence the purchase behavior of consumers. In the second project “COSUS – Consumers in a Sustainable Food Supply Chain” (BMEL, term: 2014-2017) the doctoral candidate investigated the acceptance and purchase intention of visually suboptimal food items.

Table 1 provides an overview of the articles that are part of this dissertation (shaded in grey) with associated presentations at academic conferences and further publications that used data of the original works. The complete citations of the articles that are part of this dissertation are included in the references. Two articles, C.1 and C.2, are **conceptual** works, whereas the remaining ones, E.1, E.2, and E.3 are **empirical** in nature. Bearing the guiding principles (→ chapter 1.1) and the objectives of this dissertation (→ chapter 2.1) in mind, article C.1 is interdisciplinary-oriented, whereas the other four articles consider aspects of sensory marketing (C.2), health and sensory marketing (E.1), as well as sustainability and sensory marketing (E.2, E.3). Additionally, the doctoral candidate published three further research papers related to the topics of consumer behavior³ and food science⁴.

³ Symmank, C., Hoffmann, S. (2016). Leugnung und Ablehnung von Verantwortung. In L. Heidbrink, C. Langbehn, J. Sombetzki (Hrsg.), *Handbuch Verantwortung*. Wiesbaden: Springer Fachmedien.

⁴ Böhme, B., Symmank, C., Rohm, H. (2016). Physical and sensory properties of chocolate made with lecithin of different origin. *European Journal of Lipid Science and Technology*, 118 (12), 1839-1845. (Impact Factor 1.953).

Raak, N., Symmank, C., Zahn, S., Aschemann-Witzel, J., Rohm, H. (2016). Processing- and product-related causes for food waste and implications for the food supply chain. *Waste Management*, 61, 461-472. (Impact Factor 3.829).

Table 1: Overview of publications

| Code | Publication (title) | Type of publication | Review process | VHB JOUR-QUAL 3 ^(a) | IF ^(b) |
|---------------------------------|--|---|----------------|--------------------------------|-------------------|
| Theoretical / conceptual | | | | | |
| C.1 | Predictors of food decision making: A systematic interdisciplinary mapping (SIM) review (Symmank et al. 2017) | Research paper published in <i>Appetite</i> | peer review | - | 3.125 |
| F.1 | The influence of extrinsic product attributes on consumers' food decisions: Review and network analysis of the marketing and business literature (Symmank et al. 2017) | Research paper submitted to <i>Journal of Consumer Behaviour</i> | peer review | C | 1.481 |
| F.2 | Einflussfaktoren auf die Lebensmittelauswahl: Ergebnisse des europäischen Forschungsprojektes FODEM (Symmank et al. 2017) | Research paper published in <i>Deutsche Lebensmittel-Rundschau</i> | peer review | - | - |
| P.1 | Psychological determinants of food decision making: A systematic literature review (Symmank et al. 2017) | Conference presentation at the <i>Annual Conference of the Association for Researchers in Psychology and Health (ARPH), Leiden, The Netherlands</i> | peer review | - | - |
| P.2 | Food decision making: A systematic interdisciplinary mapping review (Symmank et al. 2016) | Conference presentation at the <i>Annual Meeting of the International Society of Behavioral Nutrition and Physical Activity (ISBNPA), Cape Town, South Africa</i> | peer review | - | - |
| P.3 | Product characteristics and consumer's food decision making: A network analysis of the marketing and business literature (Symmank et al. 2016) | Conference presentation at the <i>European Marketing Academy (EMAC) Annual Conference, Oslo, Norway</i> | peer review | - | - |
| C.2 | Extrinsic and intrinsic food product attributes in consumer and sensory research: Literature review and quantification of the findings (Symmank 2017) | Research paper submitted to <i>Management Review Quarterly</i> | peer review | C | - |
| Empirical | | | | | |
| E.1 | Light and pale colors in food packaging: When does this package cue signal superior healthiness or inferior tastiness? (Mai, Symmank, Seeberg-Elverfeldt 2016) | Research paper published in <i>Journal of Retailing</i> | peer review | A | 2.014 |
| F.3 | Ambivalente Einflüsse der Verpackungsfarbe auf das Konsumentenurteil: Helle Verpackungen als Fluch oder Segen? (Symmank et al. 2017) | Research paper published in <i>Der Lebensmittelkontrolleur</i> | peer review | - | - |

Note: Publications shaded in grey are part of this compilation (for complete citation → references).
 C = conceptual work; E = empirical work; F = further publication using data of the original work; P = associated presentation of the research paper at a conference; “-“ = not available
^(a) Hennig-Thurau and Sattler (2015); ^(b) Impact Factor (Journal Citation Report 2017).

Table 1: Overview of publications (continued)

| Code | Publication (title) | Type of publication | Review process | VHB JOUR-QUAL 3 ^(a) | IF ^(b) |
|------------------|---|---|----------------|--------------------------------|-------------------|
| <i>Empirical</i> | | | | | |
| E.2 | Have an eye on the buckled cucumber: An eye tracking study on visually suboptimal foods (Helmert, Symmank et al. 2017) | Research paper published in <i>Food Quality and Preference</i> | peer review | - | 3.688 |
| P.4 | Angeschaut und eingekauft? Wie Produktlabels die Aufmerksamkeit auf visuell suboptimale Lebensmittel lenken (Symmank et al. 2016) | Conference presentation at the <i>GDL-Kongress Lebensmitteltechnologie, Lemgo, Germany</i> | peer review | - | - |
| P.5 | Visual attention on suboptimal food: An eye tracking study (Helmert, Symmank, Rohm 2016) | Conference presentation at the <i>European Conference on Sensory and Consumer Research (Eurosense), Dijon, France</i> | peer review | - | - |
| E.3 | Visually suboptimal bananas: How ripeness affects consumer expectation and perception (Symmank et al. 2018) | Research paper published in <i>Appetite</i> | peer review | - | 3.125 |
| F.4 | Konsumentenakzeptanz von optisch suboptimalen Lebensmitteln (Symmank, Rohm 2017) | Research paper published in <i>Deutsche Lebensmittel-Rundschau</i> | peer review | - | - |
| P.6 | Consumer expectation and perception of suboptimal foods: The case of bananas (Symmank et al. 2016) | Conference presentation at the <i>Nordic Conference on Consumer Research (NCCR), Aarhus, Denmark</i> | peer review | - | - |

Note: Publications shaded in grey are part of this compilation (for complete citation → references).
 C = conceptual work; E = empirical work; F = further publication using data of the original work; P = associated presentation of the research paper at a conference; “-“ = not available
^(a) Hennig-Thurau and Sattler (2015); ^(b) Impact Factor (Journal Citation Report 2017).

2.3 Notes on co-authors

The doctoral candidate is the lead author of three of the five articles included within this cumulative dissertation. The order of the authors represents the share of the participation in the conception of the study, the generation, analysis and interpretation of the data, and the preparation of the manuscript (Deutsche Forschungsgemeinschaft 2013). An exception is Harald Rohm, who is the last author of three articles, which is a usual procedure in engineering sciences. With regard to articles C.1 and E.3, the conception of the study, and the generation and analysis of the data were carried out by the doctoral candidate. The interpretation of the data as well as the preparation of the manuscript was supported by the co-authors. For article C.2, all steps of the publication process were exclusively conducted by the doctoral candidate. With regard to article E.1, the doctoral candidate supported all steps of the publication process with a focus on the conception of the studies, and the generation and interpretation of the data. For article E.2, the doctoral candidate was mainly responsible for the conception of the study, the interpretation of the data, and the preparation of the manuscript.

3 Synopsis of conceptual and empirical articles

The synopsis briefly summarizes theoretical background and objective, materials used (where required), methodological approach, and results of each article included in this dissertation. At the end of this chapter, a summary table comprises all article characteristics (→ Table 2).

3.1 Article C.1 – Predictors of food decision making: A systematic interdisciplinary mapping (SIM) review

Theoretical background and objectives

Being the first work in this dissertation, the aim of this article is to initially approach the topic of consumer food decision making from different views in order to obtain a comprehensive picture of its theoretical and scientific relevance. Different scientific disciplines have investigated a vast amount of factors influencing food decision making, leading to a large number of publications that has been steadily increasing over the last three decades. Each discipline (e.g., marketing, food science) explores the topic of food decision making from its own perspective focusing on different outcomes (e.g., purchase intention, food liking) and factors (e.g., price, ingredients). The range of individual, social, and environmental factors influencing the outcomes is impressive and has resulted in various, mostly discipline-oriented frameworks and models (Booth et al. 2001; Furst et al. 1996; Hummel and Hoffmann 2016). These frameworks and models contribute to an in-depth understanding of certain types of factors, whereas aspects from other disciplines are comparably neglected. Furthermore, these frameworks and models are static in nature and do not allow to pursue the ongoing developments in research.

The first objective of this article is therefore to provide an interdisciplinary overview to explore the state-of-the-art, and to identify hot topics and research gaps in the field of consumer food decision making. Second, the identified literature is categorized in an integrative, dynamic framework that provides greater capacity for integrating the multitude of studies than frameworks emerging from one single discipline.

Methodological approach

An extensive systematic interdisciplinary literature search in ten electronic databases (e.g., Business Source Complete, Web of Science) was conducted using a predefined keyword combination. The approach used for the literature review builds on the rapid review method as

specific form of the literature review from medicine and healthcare, and mapping techniques from information technology research. As this is an innovative variant of literature reviews this approach is denoted as systematic interdisciplinary mapping (SIM) review. After applying inclusion and exclusion criteria and excluding duplicates, the factors of food decision making analyzed in the relevant studies were categorized in line with the recently proposed DONE (Determinants Of Nutrition and Eating behavior) framework (Stok et al. 2017). This framework structures the influencing factors of nutrition and eating behavior across age groups and across research disciplines along four main levels: individual, interpersonal, environment, and policy. Within each of these main levels, factors are grouped into eleven distinct stem-categories and more specific leaf-categories.

Results

The distribution of the 1,820 publications from 485 different journals published from 1954 to 2014 indicates that research interest on food decision making was low for almost four decades. Starting with 1990, a steady increase in publication number is noticeable, with currently almost 200 publications per year. Most research is conducted in nutritional (289 publications) and medicine/health science (232 publications), followed by behavioral science and food technology. Although there are some linkages across neighboring disciplines (e.g., behavioral and nutritional science), only few publications address multiple research disciplines.

Based on the categorization of studies according to the DONE framework, this article analyzes a dataset with 2,996 entries (a multiple coding of one publications was possible). The majority of studies investigate biological and psychological factors influencing consumers' food decision making. Studies on policy-related and environmental influences are scarce. Most of the disciplines investigate factors from an individual perspective, while economics focus on environmental factors (e.g., extrinsic product attributes).

This article enables to gain a well-founded overview of existing scientific knowledge on the phenomena of decision making in the food context. Understanding of the amount and content of previous research on food decision making represents an adequate starting point for further investigations in cross- and interdisciplinary research. Moreover, this article calls to strengthen the interactions between disciplines.

3.2 Article C.2 – Extrinsic and intrinsic food product attributes in consumer and sensory research: Literature review and quantification of the findings

Theoretical background and objectives

Just as article C.1, this article C.2 is of conceptual nature. However, article C.2 provides a holistic picture and allows a deep insight into the interdisciplinary research of originally two different scientific domains – consumer and sensory science. Consumer science has been considered mainly from a business perspective, particularly the marketing discipline, and deals with food decision making. Sensory science has been mainly driven by food science and focuses on food consumption (Grunert 2015). Thus, studies in consumer food research have only rarely included tastings in their study designs. They have rather focused on the pre-purchase phase, in which consumers make food choices that might be explained by the effect of promotions or previous experiences. In contrast, studies in sensory science represent the post-purchase phase, in which the sensory impression of the food is pronounced (Grunert 2015). Having this in mind, it is evident that consumer behavior is studied by different methods that are commonly used in each discipline. Moreover, while consumer science investigates primary extrinsic product attributes (e.g., price, brand, packaging), sensory science pays special attention on intrinsic cues (e.g., appearance, smell, taste).

Although previous research has recognized the need for a joint research of both scientific streams, the amount and content of isolated and joint research, respectively, is unknown. Consequently, article C.2 aims to systematically summarize the existing knowledge about extrinsic and intrinsic product attributes in food decision making research, to reveal methods that have been used in consumer and sensory science, and to bring together this knowledge in an overarching scheme. The article concludes with implications for research and practice.

Methodological approach

The article pursues a three-staged methodological approach. As an initial step within the systematic literature review, predefined keywords were entered in an interdisciplinary electronic database. A rigorous review process including title-, abstract-, and full-text assessment, as well as content-specific and formal inclusion and exclusion criteria produced a sample of 128 studies. These articles were used for a subsequent extensive forward and backward search. The final sample consists of 602 studies that were coded regarding research methods,

intrinsic and/or extrinsic product attributes, consumer response measurement, study location, study origin, and food type. This third step serves for a quantitative content analysis.

Results

While product attributes like taste, label, and price are well researched, food appearance, smell, sound, texture, and packaging suffer from a lack of research. This article also demonstrates that there is an imbalance in the use of research methods, and that a method-mix is rarely or never applied. Most of the identified studies have been conducted as central location tests (e.g., in a sensory laboratory or market research institute) in Europe and North America. Responses of the consumers are mainly conceptualized in terms of food liking, food choice, purchase intention, and willingness-to-pay. Foods that received high research attention are beverages, dairy, and menus.

Article C.2 establishes an agenda for further research to support that consumer food decision making advances in the future through broader, at least cross-disciplinary research. On the basis of these research gaps, the empirical articles in this dissertation contribute to identify multiple new avenues concerning product attributes (e.g., food appearance: → articles E.2, E.3; texture: → article E.3; packaging: → articles E.1, E.2) and research methods (e.g., implicit association test: → article E.1; eye tracking: → article E.2; paired comparison test: → article E.3).

3.3 Article E.1 – Light and pale colors in food packaging: When does this package cue signal superior healthiness or inferior tastiness?

Theoretical background and objectives

As article C.1 shows extrinsic product attributes being of high relevance in economics, and article C.2 reveals that food packaging is underrepresented in current research, this article investigates the role of light-colored (or pale) packaging in consumers' product perception and purchase decision. While conventional wisdom suggests that products with a pale packaging is perceived "lighter" and thus healthier, it is expected to be a double-edged sword inducing two effects that work in opposite directions: On the one hand, it stimulates health perception associations; on the other hand, it raises doubts about product tastiness. This might be attributed to the assumption that an intense impression of one aspect (e.g., dark and rich colors) leads to an intense impression of another aspect (e.g., tastiness, quality, ripeness)

based on deeply rooted, color-related associations that emerge unconsciously (Becker et al. 2011; Karnal et al. 2016).

Besides the objective to investigate the opposite effect of light-colored package (Studies 1a, 1b), this article aims at contributing to a better understanding of when this package cue is an asset or a liability by elucidating the boundary conditions under which the opposing effects operate (Study 2). Therefore, this article shed light onto the moderating effect of the availability of oral sensory information and the effect of consumers' health consciousness. Furthermore, this article tests the effect of the packaging color for more or less healthy products (inter-product comparison, Studies 3a, 3b) and manipulates the healthiness dimension for the same product (intra-product comparison, Study 4). As article C.2 stresses the necessity of combining consumer and sensory research, three out of six studies in this article include a tasting of the product samples and thus covers the sensory aspect within the primarily consumer research approach.

Materials and methodological approach

To test the theoretical framework a wide range of methods was used. In a first preliminary study, an implicit association test (IAT) as a computer-based reaction-time measurement (Study 1a) explored whether consumers intuitively perceive light-colored packaging as a subtle health cue and a signal of tastiness decrease. It measured the strength of associations between a category and an attribute by using the time it takes to make the pairings. 46 participants completed two IATs, one of which measured health associations and a second one that measured tastiness associations.

In a second preliminary study, a choice experiment (Study 1b) assessed how two packages with different color intensity affect decision in a real consumption context. 84 participants were randomly assigned to one of the two framing conditions (health vs. indulgence). After the respective mindset was induced, actual choices between two cereal bars were observed.

Having demonstrated the role of food packaging as a subtle health cue, four additional experiments were conducted. In Study 2, herb cream cheese whose packaging color varied in two levels (light green and regular green) was selected as the focal product building on exploratory interviews. Overall, 179 individuals participated in the mixed-design experiment involving a 2 between-subjects (color intensity) by 2 within-subjects (accessibility of sensory information) design. In a first round (in-store situation), the participants were allocated to only one packaging condition (light vs. regular) and each of the two sub-samples had to

evaluate product tastiness and healthiness, health consciousness, and purchase intention, without tasting the product. In a second round (post-purchase consumption situation), participants had to taste the product (the same for both sub-samples) and judged again tastiness and healthiness, health consciousness, and purchase intention.

Study 3a followed the same procedure as Study 2. 206 individuals (allocated to two sub-samples) evaluated potato chips (snack product that is typically consumed for indulgence) before and after tasting. The 125 participants of Study 3b were allocated to four sub-samples as the accessibility of sensory information was a between-subject factor in this study. Fruit bars were used as product sample (snack product that is typically positioned as healthy). Study 4 put particular emphasis on the in-store situation. The study applied a 3 (color intensity: light, regular, dark) by 2 (type of color: associated with healthy vs. neutral) by 2 (type of product: associated with healthy vs. conventional) between-subjects design. The study used orange juice as product sample and included 240 participants.

Results

The results of Study 1a clearly show that participants have fewer difficulties to pair light-colored product packaging with healthy attributes. Response times were faster for compatible pairing. Thus, the IAT confirms the heuristic associations of light colors as a health cue in food packages. Study 1b demonstrates that light-colored packages affect actual product choice. Participants prefer the light-colored package when the health goal was activated, whereas they choose the regular packaging when they are searching for a tasty product.

Study 2 reveals that the effect of package color depends on whether consumers are looking at the product (in-store situation) or actually taste the product (post-purchase consumption situation, e.g., at home). Unfavorable color-induced tastiness inferences are more powerful for consumer's decision making when visual perception is available only. To infer product tastiness (which is the most important criterion for most consumers) consumers have to rely on heuristic package cues. However, when consumers are able to actually taste the product, such inferences are not necessary because oral sensory information is available. Healthiness, on the other hand, is very difficult to detect for consumers, even when tasting a product. For this reason, package color-induced health inferences occur even after tasting. Study 2 also shows that the consumer's judgment goal is a second crucial aspect that needs to be considered when determining optimal package color. The positive health effect of light-colored packages occurs primarily for health-concerned consumers. Negative tastiness associ-

ations are more likely activated by less health-conscious consumers. In both conditions, when sensory information is missing or not, only tastiness evaluations guide purchase intention.

For a product that is typically consumed for pleasure and indulgence (Study 3a), the analysis shows a negative tastiness effect of the light-colored packaging when sensory information is missing. This could be particularly observed for the less-health-conscious consumers. When sensory information is available through tasting, the negative color-induced tastiness effect disappears because tastiness is no longer a missing attribute. Confirming the results of Study 2, tastiness inferences have much greater impact on purchase intention than health inferences. Is a product typically consumed as a healthy snack (Study 3b), light-colored packages are perceived healthier than regular packages when sensory information is absent. After tasting, the product in the light-colored packaging is perceived tastier. However, only the tastiness impression guides purchase intention.

By distinguishing more than two levels of color lightness, Study 4 shows that pure squeezed orange juice with a light-green packaging is perceived most healthy, whereby a dark-blue juice package from concentrate is perceived as most tasty. This finding demonstrates that the judgments about tastiness and health additionally depend on the perceived product healthiness for the same product. For both, the green and the blue labels, purchase intention was higher for the dark packages compared to the light or regular packages.

This research provides evidence that light-colored packaging has different meanings to different consumers in different food retail environments. Consumers do not only rely on light-colored packages as a health cue, but this visual cue might simultaneously activate less favorable tastiness inferences.

3.4 Article E.2 – Have an eye on the buckled cucumber: An eye tracking study on visually suboptimal foods

Theoretical background and objective

Food and the resources exploited for its production, transportation, and disposal across the food supply chain get lost when the food is not used for the purpose of consumption. This has a dramatic negative environmental, economic, and social influence on the sustainability within the food sector (Aschemann-Witzel et al. 2015). Particularly, current western consumption patterns are associated with the consumers' unwillingness to purchase and consume so-called suboptimal or imperfect looking food. Such food deviates from regular products in terms of appearance, date labeling, or packaging, without deviation on the intrinsic

sic quality or safety (de Hooge et al. 2017). Fostering the purchase of imperfect food is one important step on the way to reduce the amount of food waste and its ecological impact caused by consumers. If those visually suboptimal food options have passed the food supply chain and reach the supermarket shelves, consumers decide about purchase or non-purchase.

As the first sensory contact to food usually is the visual one, either in terms of the product packaging or the product itself, attracting the consumers' attention is a central task in marketing. As empirical marketing research on consumer preferences for suboptimal food is scarce, the objective of this article is to investigate eye movement behavior when inspecting suboptimal foods with and without specific messages among impeccable ones in a purchase and discard decision task.

Materials and methodological approach

Eye tracking is a promising tool to gather information of what attracts consumers' attention. Thus, this article adopts the eye tracking technique to assess attention towards suboptimal food items. 30 participants inspected grids with eight foods while their eye movements were recorded. Three different kinds of grids (each including eight products) were deployed; baseline grids containing impeccable products, suboptimal grids with one visually suboptimal item among seven impeccable ones, and sublabel grids containing a suboptimal product with an additional message on a specifically designed price badge. The messages were about taste or price and were presented in red or green, resulting in four combinations. Eight food items of different product categories (e.g., fruit and vegetables, dairy) were presented in an impeccable state, the same items were photographed as suboptimal version, and these suboptimal items were additionally presented with one of the four messages ($8 + 8 + 8 \cdot 4$). These 48 relevant items were accompanied by 32 filler items (impeccable products) to fill up the grids.

The participants were informed that – after inspecting each of 136 grids – they had to answer one of two possible questions: “Which product would you remove from your shopping cart?” (discard condition) or “Which product would you keep in your shopping cart?” (purchase condition). After the participants signaled by pressing a button that they are ready, the grid was removed, and one of the questions was randomly presented. A trial was finished when one grid position was selected as response.

Dependent variables were time to first fixation (i.e., the amount of time that an individual takes to look at a specific product), total fixation duration (i.e., the period where the eyes are locked towards a product), attention distribution (i.e., the percentage of fixations fall-

ing within the price region per grid), item coverage (i.e., number of food items fixated within one trial), and food choice (i.e., the percentage of relevant items chosen per condition).

Results

The results of this article show that price badge design has an influence on eye movements. Compared to the foods presented in the baseline condition, suboptimal foods have a lower time to first fixation and longer total fixation duration. In the sublabel condition, the effects are even more pronounced. Within the sublabel condition, longer total fixation duration can be observed for red messages, regardless of the content of the message (price vs. taste). Both attention distribution and item coverage are higher in trials that contain food items with a taste message. The analysis of the choice behavior shows that when confronted with the discard question the percentage of chosen relevant items remain stable between the conditions. Within the sublabel condition, products with red color and price message are most often chosen, followed by green/taste combination. For the purchase question, choice rate of relevant items decreases from the baseline to the suboptimal condition. However, the same items are chosen more often in the sublabel condition. Within the sublabel condition, a significant influence of information can be observed with reduced prices showing a higher purchase decision rate compared to the taste information.

Consumers play a crucial role in the reduction of food waste via their in-store choices and their consumption decisions in the household. The results of this article emphasize the importance of highlighting suboptimal foods to attract consumers' attention – in terms of color or the content of the highlighted message.

3.5 Article E.3 – Visually suboptimal bananas: How ripeness affects consumer expectation and perception

Theoretical background and objective

The study in this article was conducted focusing on the same background as article E.2 pursuing a similar objective. Along with the emerging societal significance of sustainability, the acceptance of suboptimal food has come to the forefront. One reason for the significant amount of food wasted at the consumption stage is that consumers often expect products past the best-before date or visually suboptimal food to be less tasty, even though they are still palatable. Consumer decision making to buy and consume suboptimal foods strongly depends on sensory expectation and perception. As consumers attach different meanings to different

colors (as shown in article E.1 for product packaging), the natural variation of product color may also directly communicate product properties to the consumer (e.g., ripeness degree, sour-sweet ratio). By integrating sensory experiences into consumer research, this article again supports an interdisciplinary research approach that is proposed in article C.2. From prior research, it is unknown how sensory cues of suboptimal food might influence consumers' food evaluation, especially when consumers can taste these foods. Therefore, the objective of this article is to understand how appearance affects consumer expectation and perception of visually suboptimal versus impeccable bananas.

Materials and methodological approach

The ripening of the bananas is associated with a visual, but also with a physical and chemical alteration of banana properties. Therefore, the Cavendish bananas were stored at predefined conditions and analytical parameters (firmness, sugar content, and color) were measured to analyze the ripening status. This procedure ensured that the participants in the main study received comparable bananas. Bananas are commonly categorized in seven ripeness degrees, whereby ripeness degree 5 refers to a yellowish-green banana (control condition) and ripeness degree 7 to a yellow banana with brown spots (more ripened, "visually suboptimal").

As a preliminary study, a forced choice test (paired comparison test) between bananas of ripeness degree 5 and 7 with 35 semi-trained participants was conducted to identify sensory properties for the main study that are significantly different between bananas of these ripeness degrees. In the main study, 233 participants were randomly allocated to four experimental groups. Participants of group 1 and 2 received one peeled banana of either ripeness degree 5 or 7 to rate – after tasting – perception only. Participants of group 3 and 4 received one unpeeled banana of either ripeness degree 5 or 7 to rate expectation, and – after peeling and tasting – perception. More precisely, each participant had to evaluate overall liking of the banana, the satisfaction with the intensity of sensory attributes (using five-point just-about-right scales from sensory research), purchase intention, and the intended use of the bananas.

Results

Before tasting, overall liking and purchase intention are significantly lower for the unpeeled banana of ripeness degree 7 (group 4) compared to ripeness degree 5 (group 3). After tasting (groups 1 to 4), no difference in overall liking can be observed, whereas purchase intention was still significantly lower for bananas of ripeness degree 7 (group 4). This indi-

cates that sensory perception positively influences consumers' liking. However, despite tasting purchase intention rating is not positively influenced due to the initially negative visual impression of the suboptimal banana. Interestingly, males, compared to females, expressed a higher overall liking and purchase intention of the unpeeled banana with ripeness degree 7 before and after tasting.

Concerning the sensory attributes, a penalty analysis reveals that only the firmness of the bananas of ripeness degree 7 is not just-about-right after tasting. Significant differences between ripeness degree 5 and ripeness degree 7 can be observed when asking participants for their intended use of the bananas. Furthermore, the importance of the shelf-life of food has a pronounced impact on purchase intention of bananas with a different ripeness degree. Lastly, this article approaches to some communication messages that may inspire effort to test the messages in further field experiments.

In the case of suboptimal bananas, the results demonstrate a negative relationship between the suboptimal appearance of bananas in terms of ripeness with overall liking and purchase intention. Building on these insights, this article argues that sensory experience is one important factor that helps to foster consumers' acceptance of suboptimal foods. Moreover, this article highlights different implications for the supermarket setting and the home situation.

3.6 Overview of article characteristics

Table 2 summarizes the addressed research gaps, the research and methodological approach, the number of partial studies, sample sizes, key findings as well as the current status and form of the articles included in this dissertation.

Table 2: Overview of article characteristics

| Article | C.1 | C.2 | E.1 | E.2 | E.3 | |
|----------------------------------|--|--|---|--|--|------------------|
| Topic | Food decision making | Product attributes in consumer and sensory science | Food packaging colors to signal health and / or taste | Attention attraction on suboptimal foods | Sensory expectation and perception of suboptimal food | |
| Research gap | Understanding of the amount and content of previous research on food decision making | Summary of insights on interdisciplinary research in consumer and sensory science | Investigation of opposing effects of color as a package cue | Investigation of eye movement behavior on impeccable vs. visually suboptimal food | Investigation of visual inspection vs. tasting on the evaluation of impeccable vs. visually suboptimal food | |
| Research approach | Theoretical / conceptual | Theoretical / conceptual | Empirical | Empirical | Empirical | |
| Method | Systematic interdisciplinary mapping (SIM) review | Systematic literature review, content analysis | Survey, experiment, quantitative data analysis | Experiment, quantitative data analysis | Survey, experiment, quantitative data analysis | |
| Number of partial studies | - | - | 6 | 1 | 2 | |
| Sample size^(a) | n = 1,820 | n = 602 | n = 46 n = 84 n = 179 n = 206 n = 125 n = 240 | n = 30 with 136 trials per participant = 4,080 | n = 35 n = 233 | |
| Key findings | <ul style="list-style-type: none"> - First application of the DONE framework - Research focus on biological, psychological, and product-related predictors - Policy-related predictors under-researched | <ul style="list-style-type: none"> - Imbalance of research methods - Imbalance of investigated extrinsic and intrinsic product attributes - Identification of research gaps | <ul style="list-style-type: none"> - Opposing effects of packaging color occur - Identification of key boundary conditions influencing the opposing effects | <ul style="list-style-type: none"> - Different-designed price badges help to attract attention towards suboptimal food - Different-designed price badges increase purchase intention of suboptimal foods | <ul style="list-style-type: none"> - Expectation and perception differ depending on the state of the food - Positive influence of the sensory perception of suboptimal food on liking, but not on purchase intention | |
| Publication | Status | Published | Under review | Published | Published | Published |
| | Form | Original article | Original article | Original article | Original article | Original article |

Note: ^(a) Sample size refers either to the number of analyzed publications in the conceptual studies C.1 and C.2 or to the number of participants in the empirical studies E.1, E.2, E.3. In any case, these are independent samples, that were specifically and exclusively collected for the present dissertation.

4 Conclusion

4.1 Summary of research findings

The present cumulative dissertation investigates the topic of consumption decisions in the food sector by means of conceptual and empirical studies. The aim of this dissertation was presented threefold (→ chapter 2.1).

The first objective was to summarize the existing body of **prior research activities** with close consideration of relevant predictors of food choice, scientific domains, and the amount of research over time. With respect to this objective, article C.1 – at least during the process of this dissertation – is the first one that systematically reviews quantitative studies in the field of food decision making across disciplines. Although this field is tackled from different angles in single disciplines, the results of the article stresses that research lacks of interdisciplinarity. Article C.2 extensively addresses the need for interdisciplinary research from a conceptual point of view. It provides an overview of methods used to investigate extrinsic and intrinsic product attributes in consumer and sensory research. The second objective was to generate **new knowledge** at the intersection of sensory marketing, health marketing, and sustainability marketing. From the perspective of the doctoral candidate, the articles included in this dissertation successfully meet this demand. Considering the empirical studies, article E.1 for example, portrays how consumers react to light-colored packaging of different products at different parts of the purchase process. As a second major contribution, the article suggests a theoretical underpinning of the boundary conditions under which this health cue operates (e.g., availability of sensory information). With a total of six studies, article E.1 provides insights into consumer behavior at the frontier of health and sensory marketing. Against the background of food waste reduction, articles E.2 and E.3 paradigmatically demonstrate the importance of a food product's visual appearance in attracting attention, and influencing choice behavior and sensory experience. These articles are therefore prime examples of how to integrate perspectives of sustainability and sensory marketing. The superordinate goal of this dissertation was the advancement of the societal and managerial **understanding of consumers as decision makers** within the food context. All articles within this dissertation focus on the consumer perspective. Besides gaining an improved understanding of what determines the consumer's decision making behavior (article C.1), a further contribution of this dissertation lies within the quantification of previous research efforts in analyzing extrinsic and intrinsic product attributes as drivers of food decision making (article C.2). Furthermore, researchers now have a better picture of how consumers choose food when it varies in packaging color (article E.1) or in visual appearance (articles E.2, E.3). Since product experience

usually arises from the interaction between product and consumer, particularly article E.1 addresses the consumer perspective by including consumer characteristics (i.e., health consciousness) in the choice process.

Overall, the articles of this dissertation map out the limitations of consumers as utterly rational, deliberate decision makers. Consumers' food choices were shown to be rather 'comparative', in terms of comparing different products at the time of judgment (articles E.1, E.2), or comparing one available product with previous experiences (articles E.1, E.3).

4.2 Limitations and avenues for future research

Despite decades of research on the factors of food decision making and the role that food marketing plays in determining purchase and consumption, many voids are still to be filled (Chandon and Wansink 2012). This dissertation contributes to answer a handful of open questions in food research. It shows that food decision making of consumers is governed by a complex set of inter-related factors, whose magnitude and direction vary dynamically across consumer attitudes, consumption context, and type of food studied. However, the articles presented within this dissertation are not free from limitations. There are three general restrictions that are present in various articles of this dissertation. First, the participants of the empirical studies (articles E.1, E.2, E.3) are embedded within the **German food system**. Although the attempt was made to ensure international applicability of study results, future studies need to replicate the empirical results in non-German food settings (e.g., with different color associations → article E.1; or where the value of suboptimal foods is announced more publicly, like the “inglorious fruits and vegetables” campaign of the French retailer Intermarché → articles E.2, E.3). Second, the empirical research was conducted under the condition that consumers were aware of the **study context**. Additionally, the research is based on consumers' self-reported intentions to buy and consume the presented foods. This dissertation therefore stresses the necessity to test generalizability of the findings by conducting studies in a non-obtrusive real-life environment as consumers might behave differently (e.g., in stores or online shops). Future research is also needed that carefully considers store and consumer characteristics (e.g., for a consumer segmentation). Third, the conceptual articles represent only a **static picture of research activities**. However, the dissemination of the dissertations' contribution hopefully stimulates further research on the topic of consumption decisions.

As each article discusses its limitations at the end, Table 3 highlights the most important avenues for future research, divided into research content and research methodology. Awaiting future research addressing these and other issues, the findings of this dissertation particularly attest to the importance of interdisciplinary research in food marketing.

Table 3: Avenues for future research

| Subject | Description |
|------------------------------------|---|
| <i>Research content</i> | |
| Consumption decision | <ul style="list-style-type: none"> - Intensifying research on factors of food decision making and their interaction - Considering the various stages of consumer-product interaction (e.g., attention, expectation, perception, experience) |
| Healthy food choice | <ul style="list-style-type: none"> - Investigating potential trade-offs of short-term (e.g., taste) and long-term product benefits (e.g., health) - Validating how subtle cues (e.g., package color) influence healthful food choices - Focusing on research on the influence of supposed positive package health cues (e.g., health claims, light colors) on other valued characteristics of the food (e.g., food quality) and the raising ambivalent effects - Examining how the ambivalent effects hold for ‘neutral’ products that are neither healthy nor unhealthy (e.g., margarine) |
| Packaging characteristics | <ul style="list-style-type: none"> - Investigating the meaning of colors in different cultural and social backgrounds - Deeper understanding of the different color appearance parameters (hue, lightness, chroma, saturation) and their isolate and joint effect on consumers’ color perception - Testing the effect of packaging color for further product categories (e.g., meat) - Paying attention on interacting packaging characteristics (e.g., color and shape, color and size, color and material) when transporting a specific message - Investigating how packaging impacts consumers in a physical versus online store |
| Sustainable food choice | <ul style="list-style-type: none"> - Establishing research on suboptimal foods within the vast number of sustainability issues (e.g., claims, labels) - More research regarding the degree (e.g., bruises versus ripeness) and type (e.g., food shape versus date labeling) of suboptimality in foods - Investigating the sensitivity of consumers to discounts and other messages that promote choices of suboptimal food |
| Multisensory food studies | <ul style="list-style-type: none"> - Considering multiple senses in the new product development process (e.g., taste, smell, texture/haptic) - Paying more attention on time-displaced effects of product attributes (first purchase: visual cues; repeated purchase: sensory perception with all senses) |
| Economic relevance | <ul style="list-style-type: none"> - Focusing on research on the impact of offering suboptimal food on the profitability for the food industry, retail, and consumer |
| <i>Research methodology</i> | |
| Interdisciplinarity | <ul style="list-style-type: none"> - Strengthening interdisciplinary research efforts in consumers’ food research - Using knowledge, theories, and methods from neighboring (e.g., nutritional science, behavioral science) and distant scientific disciplines (e.g., medicine, food science) to understand food decision making |
| Methodology / study setting | <ul style="list-style-type: none"> - Focusing on multi-method approaches to obtain a more complete picture of consumers’ decision making and concealed affective and cognitive mechanisms - Paying attention on the intention-behavior-gap by finding ways to collect more behavior-related data - Examining food evaluation with additional dependent variables (e.g., willingness-to-pay) - Testing whether product evaluation remains stable over time or whether it fades out over repeated exposure or choice (longitudinal study designs) - Increasing research efforts in online contexts due to the growing food e-commerce - Establishing more research in diverse food choice settings (e.g., labor, field, home-use) - Within field studies, making a distinction between different store types (e.g., discount supermarkets versus organic supermarkets) to cover different consumer lifestyles and personalities - Working on how to do research on food decision making more comparable across study settings - Conducting non-artificial field experiments |

4.3 Implications for food industry, marketers, and food policy

Because of the relevance of food for everyday life and particularly in the light of heightened **worldwide awareness** on encouraging healthful and sustainable food consumption, this dissertation has broad practical implications. The research of this dissertation was conducted with the focus on these key topics in the food sector (→ chapter 1.1). However, practitioners should be aware of the dynamic nature of food markets and consumer preferences through demographic change (i.e., increasing demand for healthy products and smaller packaging sizes), increasing urbanization (i.e., challenging logistic processes in supply and disposal), technological advances (i.e., increasing industrialization, advent of new social media), shortage of resources (i.e., over-production and -consumption), and economic growth in emerging countries (i.e., new consumer markets and opportunities for global expansion) (PwC 2014). In the light of these developments, Table 4 shows a snapshot of the most important implications for food industry, marketers, and food policy. Considering these implications might provide considerable **financial benefits** for the actors of the food supply chain and **societal benefits** such as better health, improved well-being, and employment.

Table 4: Implications for food industry, marketers, and food policy

| Subject | Description |
|-----------------------------------|--|
| <i>Food industry</i> | |
| Segmentation and targeting | <ul style="list-style-type: none"> - Designing products for specific target groups based on situational (e.g., first versus re-purchase) and individual characteristics (e.g., health consciousness, environmental concerns) - Using package color strategically |
| Competitiveness | <ul style="list-style-type: none"> - Avoiding undermining packaging effectiveness and thus the effect on sales and profits - Using colors as a low-cost way to influence consumers' attention and choice probability - Enhancing overall product experience by appealing multiple human senses - Increasing the availability of sampling opportunities as a more powerful and cheaper way compared to traditional forms of advertising |
| Relationship management | <ul style="list-style-type: none"> - Considering the power of consumers to influence product success or failure and thus integrating them at an early stage of the product development process - Fostering cooperation and developing business opportunities along the whole food supply chain to reduce food waste |

Table 4: Implications for food industry, marketers, and food policy (continued)

| Subject | Description |
|-----------------------------------|--|
| <i>Marketers</i> | |
| Distribution and pricing | <ul style="list-style-type: none"> - Carefully selecting a store type for healthy or sustainable foods (e.g., discount supermarkets versus organic supermarkets) based on consumers' lifestyle and willingness-to-pay - Incentivizing the purchase of suboptimal food by lowering prices |
| Product and positioning | <ul style="list-style-type: none"> - Actively offering a broader range of healthy and sustainable (here: suboptimal) food - Allowing tastings by product sampling or front cooking to reduce negative taste effects (for both light-colored packaged food and suboptimal food) - Designing efficient ways to present healthy and sustainable food products (retail outlets, restaurant menus, online stores) - Including suboptimal products in the standard assortment - Referring to health or environmental benefits should be applied cautiously when addressing target segments for which health or sustainability is not the overarching priority - Promoting strengths of healthy and sustainable food in addition to their primary benefits (e.g., tastiness) - Facilitating healthy or sustainable food choices and consumption by displaying and positioning food in a specific manner (nudging) |
| Communication | <ul style="list-style-type: none"> - Understanding the power of packaging color as subtle cue to influence consumers - Considering the ambivalent effects of light-colored packaging - Critically examining the applicability of universal color associations - Employing darker tones for healthier options as one way to compensate a perceived tastiness decrease - Communicating different messages to target groups when promoting healthy and sustainable food (e.g., taste message versus health message/sustainable message versus price message) |
| <i>Food policy</i> | |
| Information and education | <ul style="list-style-type: none"> - Providing information and knowledge about health and sustainability via various sources and across extensive geographic areas - Educating consumers in food skills (e.g., using senses to evaluate the food) - Differentiating knowledge transfer between purchasing behavior at supermarkets or consumption behavior at home |
| Government / legal actions | <ul style="list-style-type: none"> - Avoiding misleading conclusions about healthy and sustainable food by standardizing and simplifying product labeling (e.g., keyhole-label in Sweden, Norway, Denmark) - Establishing (economic) conditions that increase the pressure to develop concepts of how to present and sell suboptimal foods in retail outlets - Facilitating ways for industry and marketers to offer suboptimal food |
| Public image | <ul style="list-style-type: none"> - Highlighting the positive aspects of healthy and sustainable food consumption (e.g., well-being, appreciation of food) instead of the negative aspects (e.g., avoiding diseases, reducing food waste) - (Financially) supporting initiatives that aim at enhancing healthy and sustainable food consumption |

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Part II: Included articles

C.1 Predictors of food decision making: A systematic interdisciplinary mapping (SIM) review

Claudia Symmank, Robert Mai, Stefan Hoffmann, F., Marijn Stok, Britta Renner, Nanna Lien, Harald Rohm

Erschienen in: Symmank, C., Mai, R., Hoffmann, S., Stok, F. M., Renner, B., Lien, N., Rohm, H. (2017): Predictors of food decision making: A systematic interdisciplinary mapping (SIM) review. *Appetite*, 110, 25-35.

<https://doi.org/10.1016/j.appet.2016.11.023>

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C.2 Extrinsic and intrinsic food product attributes in consumer and sensory research: Literature review and quantification of the findings

Claudia Symmank

Erschienen in: Symmank, C. (2017): Extrinsic and intrinsic food product attributes in sensory and consumer research: Literature review and quantification of the findings. *Management Review Quarterly*, online first.

<https://doi.org/10.1007/s11301-018-0146-6>

p. 77

E.1 Light and pale colors in food packaging: When does this package cue signal superior healthiness or inferior tastiness?

Robert Mai, Claudia Symmank, Berenike Seeberg-Elverfeldt

Erschienen in: Mai, R., Symmank, C., Seeberg-Elverfeldt, B. (2016): Light and pale colors in food packaging: When does this package cue signal superior healthiness or inferior tastiness?. *Journal of Retailing*, 92 (4), 426-444.

<https://doi.org/10.1016/j.jretai.2016.08.002>

p. 123

E.2 Have an eye on the buckled cucumber: An eye tracking study on visually suboptimal foods

Jens R. Helmert, Claudia Symmank, Sebastian Pannasch, Harald Rohm

Erschienen in: Helmert, J. R., Symmank, C., Rohm, H. (2017): Have an eye on the buckled cucumber: An eye tracking study on visually suboptimal foods. *Food Quality and Preference*, 60, 40-47.

<https://doi.org/10.1016/j.foodqual.2017.03.009>

p. 174

E.3 Visually suboptimal bananas: How ripeness affects consumer expectation and perception

Claudia Symmank, Susann Zahn, Harald Rohm

Erschienen in: Symmank, C., Zahn, S., Rohm, H. (2018): Visually suboptimal bananas: How ripeness affects consumer expectation and perception. *Appetite*, 120, 472-481.

<https://doi.org/10.1016/j.appet.2017.10.002>

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Author's note

Please note that all research articles – independently of their status of publication (→ Table 2, p. 30) – are shown in manuscript form to allow a consistent reading. However, figures, tables, statistical reporting, and references are not reformatted and are exactly shown as submitted to or published within the respective journal. Footnotes in Part II are consecutively numbered to Part I.

C.1 – Predictors of food decision making: A systematic interdisciplinary mapping (SIM) review

Abstract

The number of publications on consumer food decision making and its predictors and correlates has been steadily increasing over the last three decades. Given that different scientific disciplines illuminate this topic from different perspectives, it is necessary to develop an interdisciplinary overview. The aim of this study is to conduct a systematic interdisciplinary mapping (SIM) review by using rapid review techniques to explore the state-of-the-art, and to identify hot topics and research gaps in this field. This interdisciplinary review includes 1,820 publications in 485 different journals and other types of publications from more than ten disciplines (including nutritional science, medicine/health science, psychology, food science and technology, business research, etc.) across a period of 60 years. The identified predictors of food decision making were categorized in line with the recently proposed DONE (Determinants Of Nutrition and Eating behavior) framework. After applying qualitative and quantitative analyses, this study reveals that most of the research emphasizes biological, psychological, and product-related predictors, whereas policy-related influences on food choice are scarcely considered.

Keywords

Food Decision Making, Food choice, Predictors, Interdisciplinary, Mapping Review, Consumer Behavior

1 Introduction

The topic of food decision making is central to many research disciplines, including nutritional science (Hoppert, Mai, Zahn, Hoffmann, & Rohm, 2012; Keim, Forester, Witbracht, Widaman, & Laugero, 2012; Vella, Stratton, Sheeshka, & Duncan, 2014), psychology (Chandon & Wansink, 2012; Hollands, Prestwich, & Marteau, 2011; Renner, Sproesser, Strohbach, & Schupp, 2012; Rozin, 1996; Wohldmann, 2013), business research (Ackermann & Palmer, 2014; Carroll & Vallen, 2014), and food science and technology (Jaros, Thamke, Raddatz, & Rohm, 2009; O'Neill, Hess, & Campbell, 2014). Each discipline contributes to the knowledge on food decision making from its own point of view and with its unique theories and methods. Despite a growing number of publications and although the disciplines share the same topic, there is still potential to merge findings. Some time ago, Köster (2009) highlighted that many factors jointly determine food choice, but interdisciplinary approaches are still scarce. The large amount of literature with heterogeneous, sometimes contradictory findings calls for ways to synthesize and generalize evidence about the key factors that guide food choice.

The scientific disciplines that explore food decision making focus on different aspects, behaviors, and mechanisms. Comparing respective studies is particularly challenging because different terms may be used for similar concepts, or because identical terms may be used for different concepts. In the marketing and consumer behavior literature, food decision making has been conceptualized, for instance, in terms of purchase intention or purchase decision (Baker, McCabe, Swithers, Payne, & Kranz, 2015; Mai & Hoffmann, 2015; Papies, Potjes, Keesman, Schwinghammer, & van Koningsbruggen, 2014; Tirelli & Martínez-Ruiz, 2014), or food choice (Carroll & Vallen, 2014; Peters-Teixeira & Badrie, 2005). In the food science and technology literature, food acceptance or preference (Alm, Olsen, & Honkanen, 2015; García-Segovia, Harrington, & Seo, 2015; Hoppert et al., 2013; Miyagi & Ogaki, 2014) are commonly related to food decision making, and psychological research has a stronger focus on eating behavior (Schüz, Schüz, & Ferguson, 2015; Sproesser, Schupp, & Renner, 2013).

The aim of the present study is to achieve an enhanced understanding of the predictors of food decision making of adults. We intend to provide a comprehensive overview of existing knowledge in order to identify gaps in the literature, and to unravel promising contributors that are apparently under-researched. Our main research questions (RQ), derived from this general aim, focus on categorizing and structuring the research in food decision making:

RQ 1: What are the main disciplines that examine food decision making?

RQ 2: What are the predictors of food decision making that are mainly addressed, and which predictors suffer from a lack of research?

RQ 3: What are the most common predictors analyzed in the various disciplines?

RQ 4: In what way did the number and frequency of publications, and topics change over time?

To achieve these goals, we conduct an extensive and systematic screening of the current literature. More precisely, to obtain a better overview on the actual scientific discussion, and on research gaps that need to be addressed in interdisciplinary work, (a) we are looking at individual cognitive and affective processes that are mainly examined in psychology, consumer behavior research, and neuroscience, (b) we consider biological predictors, sensory processes and the influence of intrinsic product attributes to cover food science and technology, nutritional science, biology, and medicine, and (c) we focus on predictors within the physical and social environment of consumers that play a major role in sociology, marketing, and social psychology.

2 Conceptual background: The DONE framework

The conceptual frameworks of food decision making that are available (e. g., Booth et al., 2001; Furst, Connors, Bisogni, Sobal, & Falk, 1996; Köster, 2009; van der Merwe, Kempen, Breedt, & de Beer, 2010) have in common that they generally stem from one specific discipline (Köster, 2009), or that they focus only on specific factors that affect food choice (Booth et al., 2001). Keeping these limitations in mind, the interdisciplinary DONE framework (Determinants Of Nutrition and Eating behavior framework) was recently developed to structure food choice determinants and influencing factors (Stok et al., 2016; Fig. 1). The aim of this framework is to identify all determinants of nutrition and eating that are relevant across age groups, and across research disciplines. It is intended as a dynamic, interactive framework that evolves and improves as experts can continue to contribute to it. The DONE framework is meant to facilitate the evolvment of a “common language” across disciplines, and to encourage collaboration and joint research efforts between the disciplines.

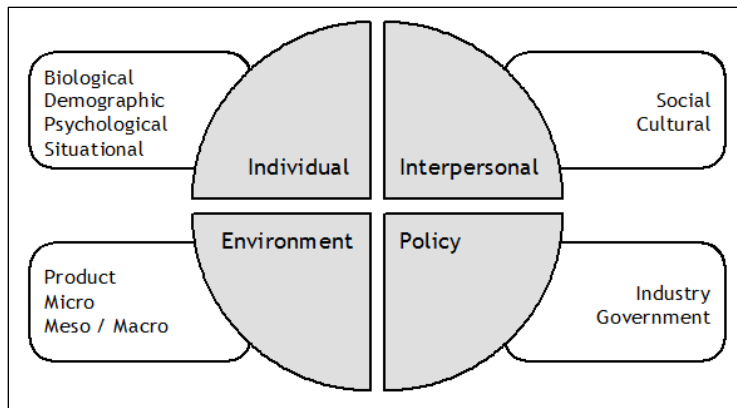


Fig. 1. Simplified representation of main levels (grey) and stem-categories (white) in the DONE framework.

The DONE framework was developed, evaluated and visualized in a multiphase process over a period of almost two years. The work took place in the context of the European research network and knowledge hub DEDIPAC (Determinants of Diet and Physical Activity) (Lakerveld et al., 2014). One working group with more than 80 scholars of different academic background was assigned to develop a multidisciplinary life-course framework of the determinants of nutrition and eating. This group of DEDIPAC partners developed the DONE framework in two steps. After creating a taxonomy of relevant outcomes (food choice, intake of nutrients, eating behavior, etc.) for which the DONE framework should provide potential determinants, the partners systematically nominated relevant determinants per age group (children – adults – elderly) and integrated and categorized these determinants into one life-course framework. The framework follows a socio-ecological structure, with determinants being structured along four main levels of influence: individual, interpersonal, environment, and policy. Within each of these main levels, determinants are grouped into eleven distinct stem-categories (see Fig. 1). Each stem-category is further subclassified into 51 more specific leaf-categories of which 47 currently exist in the framework of determinants shaping nutrition and eating of adults.

For the evaluation of the framework, the DEDIPAC partners as well as 123 external experts from different disciplines and different countries rated the determinants on the dimensions modifiability, relationship strength and population-level effect to identify areas of priority for research. In the second step, 129 external experts with different background evaluated the usefulness, completeness and applicability of the DONE framework for research, intervention, and policy making. Feedback from the evaluation phase was incorporated into the framework. The current, visualized version of the DONE framework is freely accessible and can be utilized in a highly flexible and interactive way (www.uni-konstanz.de/DONE). The

441 determinants⁵ that are currently included can be filtered, selected, sorted, and visualized for specific research questions, but also for more general overview approaches. Moreover, new determinants and categories can continuously be added to the framework, and the framework's evolution can be tracked and recorded.

3 Design

3.1 Research approach

To the best of our knowledge, no study has attempted to synthesize the literature on food decision making across different disciplines. Given that traditional review methods have severe limitations, previous interdisciplinary reviews on food choice are centred on specific domains to handle a large number of publications (e.g., Hollands et al., 2015). This work examines prior investigations at the meta-level of the food decision making complex by applying a method that we denote as systematic interdisciplinary mapping (SIM) review. Our SIM approach builds on the rapid review method, a specific form of literature review that synthesizes evidence in a shortened time frame and that is widely used in medicine and healthcare (Brearley et al., 2011; Harker & Kleijnen, 2012; Khangura, Polisena, Clifford, Farrah, & Kamel, 2014). We extend this method by integrating mapping techniques from information technology research which do neither discuss and aggregate the outcomes of the primary studies nor extract specific details, but rather analyze research activities and aggregate studies within sub-topics of defined categories (Kitchenham, Budgen, & Pearl Brereton, 2011; Li, Avgeriou, & Liang, 2015; Pedreira, García, Brisaboa, & Piattini, 2015). Both review types use methods to accelerate or streamline conventional systematic review processes by, for instance, searching in fewer databases, and considering time or scope constraints (Ganann, Ciliska, & Thomas, 2010; Grant & Booth, 2009).

3.2 Search process

3.2.1 Selection of data sources and search strategies

To achieve a comprehensive overview about interdisciplinary research in food decision making, we searched ten electronic databases: Academic Search Complete, Business Source Complete, Cinahl, EconLit, PsycArticles and PsycInfo of EBSCO, Embase, PubMed, Web of Science, and Cochrane. The variation in database profiles ensured that publications of the most important research domains were covered, e. g., nutritional science, (evidence-based)

⁵ Note: As causality was not checked, we further use the term predictor instead of determinant in this study.

medicine, business administration, behavioral science, food science and technology, and psychology.

‘Food decision making’, ‘food choice’, ‘food purchase intention’, etc. are often used interchangeably to describe the behavior of individuals in which they decide for (or against) particular foods and beverages. The use of the respective term depends on the discipline in which food consumption is analyzed, and on the background of the researcher. In the initial stage of this study, we identified the most common terms by conducting test searches and by evaluating references in sample articles. Because our focus is on quantitative studies that can be linked to the predictors, we added methodological keywords for identifying empirical papers (David & Han, 2004). After conducting a first title screening, we identified several studies that deal with animals or age groups that are not in the focus of the present research. For this reason, we added two exclusion criteria in our keyword combination (Table 1).

Table 1. Keyword combination used in this study.

| Aim of the keyword | Execution ^a |
|-------------------------------|--|
| Relevant dependent variables | "food purchase intention*" OR "food purchase behavior" OR "food purchase decision*" OR "food buying intention*" OR "food buying behavior" OR "food buying decision*" OR "food decision making" OR "food acceptance*" OR "food preference*" OR "food choice*" |
| Methodological keywords | AND (data OR regression OR empiric* OR variance OR evidence OR sampl* OR statistic* OR analysis OR signific* OR hypothes*) |
| Exclusion of animal studies | AND NOT (animal*) |
| Exclusion of young age groups | AND NOT (child* OR infant*) |

^a Keyword combination is for all databases except PubMed. Search terms were adapted to respective database syntax to achieve valid results. For PubMed we used a specific combination of Mesh Terms: (food preferences/statistics and numerical data) AND humans. *, wildcard indicator.

3.2.2 Inclusion and exclusion criteria

To ensure that only relevant articles are included in the final analysis, we identified three types of exclusion criteria: publication-based, content-based, and method-based criteria. The publication-based criterion controls for the fact that only academic journals, PhD theses, books or book sections, working papers and conference proceedings were considered. Non-academic articles, opinions, and experience papers were excluded. The content-based criterion eliminates articles which do not focus on food decision making (e. g., studies on the role of food in certain diseases). Due to the focus on human adults, we excluded all studies on animals, children, and infants (although the keyword combination contained these exclusion cri-

teria, we received a number of hits that had to be dropped). From a methodological standpoint, the search terms had to appear in the title, in the abstract, or in the keywords of the article. In addition, the article should contain empirical analysis that is accompanied by information on sample size, statistical tests, and analytic techniques. In line with our primary research objective, conceptual papers, qualitative studies, overviews, or reviews were excluded. We considered papers without any time constraints because RQ 4 addresses the changes over time.

3.2.3 Identification of relevant publications

For the search process, we applied a stepwise approach that is illustrated in Fig. 2. The initial search revealed 10,380 entries in all databases. Two researchers independently screened titles and, if necessary, abstracts and keywords using the predefined inclusion and exclusion criteria. If a discrepancy about the inclusion of a publication occurred, the two researchers re-read and discussed the paper until they agreed. To minimize the risk of (falsely) eliminating relevant publications, the critical papers were thoroughly checked. After removing publications without available full text, 5,328 publications remained across all databases. After removing all duplicates, the final sample included 1,820 unique relevant publications.

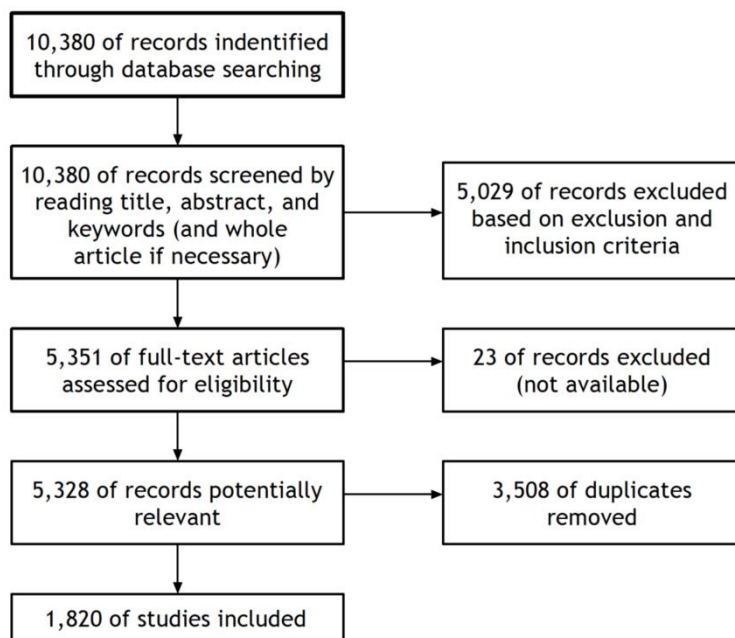


Fig. 2. Illustration of the search process.

The final dataset contained different types of publications: articles in academic journals (1,737), PhD theses (57), and other outlets (26), including book sections, conference proceedings, books, and working papers. The articles were published in 485 journals (Table S1).

The journal with the highest number of respective publications was *Appetite* ($n = 244$), followed by *Food Quality and Preference* ($n = 113$), and the *Journal of the American Dietetic Association* ($n = 79$). In ten more journals, the number of publications was larger than 20.

Of the 1,820 publications, 96.8% were published in English, 1.8% (= 33 articles) in one other language (16 Spanish, 6 Portuguese, 4 French, and some more), and 1.4% (= 26 articles) in another language with an English summary.

3.3 Coding of predictors and disciplines

In the next step, we categorized the predictors that are investigated in the 1,820 publications according to the DONE framework of food choice and eating behavior of adults. Two researchers independently analyzed the titles, abstracts and (if necessary) full texts of the publication to identify all predictors that the primary studies have examined. If there were doubts about the classification of a publication or disagreement between the researchers, the coding scheme that builds on the DONE framework was refined. That is, categories were added, expanded, or modified. Otherwise, both researchers discussed the issue until they achieved agreement. In this case, previously classified publications were checked again to validate their classification within the refined scheme. This iterative procedure proved to be very helpful as it led to a stable classification scheme after approximately 50 articles.

To assess coding reliability, a researcher with another scientific background coded a subsample of 100 randomly selected publications. We calculated the agreement between both coders for their leaf-category codings of the DONE framework. Across the eleven stem-categories, mean Krippendorff's alpha indicated acceptable agreement ($\alpha = .74$; see Hayes & Krippendorff, 2007). High agreement was also obtained when shifting the perspective by looking at the reliability of the coding of each paper. In this second agreement test, we checked whether both researchers independently assigned a paper to the same leaf-category. If both coders did not place a publication into any leaf-category, this was also counted as agreement (because multiple answers were possible). Regarding the agreement that is based on the coding of one leaf-category, this rather conservative test indicated an agreement of 77%. If multiple leaf-categories are considered for each paper, the agreement ranged from 84 % (agreement on three categories) over 92% (agreement on seven categories) to 99% (taking all possible categories into account) which is due to the large number of empty categories per paper.

As the DONE framework is an interdisciplinary approach to classify the research efforts in food decision making, we also aimed at revealing relations between the disciplines. To operationalize the disciplines in which studies on food decision making are published, we

used the journal as a proxy. The scope of an individual journal was extracted from the journal description in Web of Science, and one to three disciplines were assigned to a journal (e. g., *Appetite*: behavioral science and nutritional science; see Table S1). When a journal was not listed, we referred to Research Gate and Scientific Journal Rankings, or we visited the respective journal website (the same applies to books, book sections, PhD theses and conference proceedings). Subsequently, we grouped the journals (respectively the other types of publications) into ten disciplines: nutritional science, medicine/health science, food science and technology, behavioral science, biology, psychology, marketing and consumer research, social psychology, business administration and economics, and sociology.

4 Findings

4.1 Disciplines dealing with food decision making (RQ 1)

As a first result, we obtained a dataset of 2,996 codings coming from 1,820 publications (some publications examined multiple predictors) (Table 2). It is important to note that, because of the inductive coding procedure, some of the 39 leaf-categories presented here differ from the 51 leaf-categories in the conceptual DONE framework (Stok et al., 2016). Four of these twelve additional DONE leaf-categories do not apply in the present context because they are specific to children and thus they are not within the scope of this paper. Seven DONE leaf-categories were matched here under two umbrella terms due to different wordings in the coded studies (for further details, see Table 2). For example, ‘social support’, ‘family structure’, ‘family food culture’, and ‘household socio-economic status’ (DONE framework) were merged into one broader category that we labeled as ‘social influence’. In addition, five leaf-categories from the DONE main levels environment and interpersonal have so far been neglected in the food decision making literature (these leaf-categories are provided in Table 2 for transparency, but they are not further discussed in this article). Finally, based on the literature screening, two leaf-categories were added (see Table 2).

Table 2. Predictors of the DONE framework with the number of entries.

| Predictors main level ^a | Predictors stem-category | Predictors leaf-category |
|------------------------------------|--------------------------------------|---|
| Individual (1,853) | Biological (385, 20.8%) | Brain Function (23) Oral Function (15) Food-related Physiology (74) Anthropometrics (81) Sensory Perception (78) Physical Health (100) Sleep Characteristics (14) |
| | Demographic (440, 23.7%) | Biological Demographics (213) Cultural Characteristics (143) Situational Demographics (0) [†] Personal Socio-Economic Status (84) |
| | Psychological (905, 48.8%) | Personality (145) Mood and Emotions (53) Self-Regulation (27) Health Cognitions (60) Food Knowledge, Skills and Abilities (114) Food Beliefs (247) Food Habits (43) Eating Regulation (43) Weight Control Cognitions and Behaviors (89) Intervention (84)* |
| | Situational (123, 6.6%) | Hunger (23) Related Health Behaviors (51) Situational and Time Constraints (49) |
| Interpersonal (197) | Social (178, 90.4%)** | Social Influence (178) |
| | Cultural (19, 9.6%)*** | Cultural Cognitions, Cultural Behaviors (19) |
| Environment (922) | Product (768, 83.3%) | Intrinsic Product Attributes (265) Extrinsic Product Attributes (388) Food Type (115)* |
| | Micro (70, 7.6%) | Portion Size (6) Home Food Availability and Accessibility (16) Eating Environment (48) |
| | Meso / Macro (84, 9.1%) | Natural Conditions (0) [†] Characteristics of Living Area (13) Environment Food Availability and Accessibility (40) Food Outlet Density (4) Exposure to Food Promotion (22) Market Prices (0) [†] Societal Initiatives (5) |
| Policy (24) | Industry (1, 4.2%) | Industry Regulations (1) Industry Influence (0) [†] |
| | Government (23, 95.8%) | Governmental Regulations (4) Campaigns (19) Broader Governmental Policies (0) [†] |

^a Numbers in parentheses indicate how often the predictor was analyzed (n = 2,996, resulting from a total of 1,820 publications). The category scheme is adopted from the DONE framework (Stok et al., 2016) and slightly adapted. The two new leaf-categories that were inductively found in the literature screening and which are not part of the conceptual DONE framework are marked by an asterisk (*). Leaf-categories that have to do with parents (e. g., parental attitudes, parental behaviors) apply exclusively to children. They are thus by definition not applicable to our article. The leaf-categories family structure, family food culture, household socio-economic status, social support and social influence were merged to 'social influence' (**). The leaf-categories cultural cognitions and cultural behaviors were merged into one leaf-category (***). Predictors from five leaf-categories from the DONE framework have not yet been researched in the food decision making literature. These leaf-categories are included in this table for completeness' sake, but not discussed in the remainder of the article (†).

The analysis revealed a wide range of research disciplines dealing with food decision making. In total, 320 journals (with 885 articles and 63 other types of publications) are assigned to a single discipline, 145 journals (797 articles and 14 other types of publications) to two disciplines, and 20 journals (55 articles and 6 other types of publications) to three disciplines. This means that more than half of the research on food decision making comes in what we denote as single-discipline journals (320 of 485 journals), whereas fewer journals have a cross-disciplinary scope or even a broader interdisciplinary focus. When considering the primary discipline only, the analysis revealed a dominance of medicine/health science (125 journals with 221 articles and 11 other types of publications = 232), psychology (53 journals with 100 articles and 17 other types of publications = 117), and nutritional science (30 journals with 277 articles and 12 other types of publications = 289; Fig. 3). Within the publications in two-discipline journals, nutritional science (34 journals with 539 articles and 4 other types of publications = 543), medicine/health science (38 journals with 67 articles and 6 other types of publications = 73), and psychology (26 journals with 68 articles and 4 other types of publications = 72) dominate. Although food science and technology (55 journals with 283 articles and 10 other types of publications = 293) and behavioral science (16 journals with 257 articles and 1 other type of publication = 258) have strong relations to a second discipline, they have weaker ties to a third discipline. The same is true for publications in marketing/consumer research, social psychology, and sociology.

| | | Secondary discipline | | | | | | | | | | | Total |
|--------------------|-------|----------------------|-----|----|----|----|----|----|----|----|----|------|-------|
| | | NS | MH | FT | BS | B | P | MC | SP | BA | S | None | |
| Primary discipline | NS | – | 8 | 3 | 1 | 30 | 0 | 0 | 0 | 8 | 0 | 289 | 339 |
| | MH | 58 | – | 1 | 11 | 6 | 21 | 0 | 1 | 2 | 5 | 232 | 337 |
| | FT | 150 | 1 | – | 1 | 1 | 3 | 10 | 0 | 33 | 0 | 94 | 293 |
| | BS | 225 | 5 | 8 | – | 11 | 4 | 0 | 0 | 0 | 0 | 5 | 258 |
| | B | 69 | 15 | 3 | 0 | – | 35 | 0 | 0 | 1 | 0 | 73 | 196 |
| | P | 12 | 23 | 0 | 4 | 2 | – | 3 | 0 | 6 | 0 | 117 | 167 |
| | MC | 1 | 1 | 0 | 0 | 0 | 9 | – | 0 | 17 | 0 | 80 | 108 |
| | SP | 28 | 17 | 0 | 0 | 0 | 0 | 0 | – | 0 | 1 | 32 | 78 |
| | BA | 0 | 3 | 6 | 0 | 0 | 0 | 4 | 0 | – | 0 | 22 | 35 |
| | S | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | – | 4 | 9 |
| | None | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | – | 0 |
| | Total | | 543 | 73 | 21 | 22 | 50 | 72 | 17 | 1 | 67 | 6 | 948 |

| | | Tertiary discipline | | | | | | | | | | | Total |
|----------------------|-------|---------------------|----|----|----|---|----|----|----|----|---|------|-------|
| | | NS | MH | FT | BS | B | P | MC | SP | BA | S | None | |
| Secondary discipline | NS | – | 1 | 0 | 0 | 2 | 1 | 1 | 0 | 1 | 0 | 537 | 543 |
| | MH | 6 | – | 1 | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 61 | 73 |
| | FT | 1 | 0 | – | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 12 | 21 |
| | BS | 4 | 0 | 0 | – | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 22 |
| | B | 0 | 12 | 0 | 0 | – | 0 | 0 | 0 | 0 | 0 | 38 | 50 |
| | P | 0 | 0 | 0 | 0 | 0 | – | 0 | 0 | 1 | 0 | 71 | 72 |
| | MC | 0 | 0 | 0 | 0 | 0 | 0 | – | 0 | 4 | 0 | 13 | 17 |
| | SP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | – | 0 | 0 | 1 | 1 |
| | BA | 0 | 3 | 0 | 2 | 0 | 0 | 8 | 0 | – | 0 | 54 | 67 |
| | S | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | – | 6 | 6 |
| | None | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 948 | 948 |
| | Total | | 11 | 16 | 1 | 2 | 12 | 4 | 9 | 0 | 6 | 0 | 1759 |

Fig. 3. Relationship between primary, secondary and tertiary discipline. NS, nutritional science; MH, medicine/health science; FT, food science and technology; BS, behavioral science; B, biology; P, psychology; MC, marketing/consumer research; SP, social psychology; BA, business administration/economics; S, sociology.

4.2 Predictors of food decision making (RQ 2)

The analysis of the 1,820 publications with 2,996 codings revealed that the majority of the studies investigate predictors of food decision making at the individual level (61.8%) (Fig. 4). Approximately one third of the predictors include environmental aspects (30.8%). Studies dealing with interpersonal relations represent 6.6%, while it appears that policy-related studies are rare in food decision making research (0.8%).

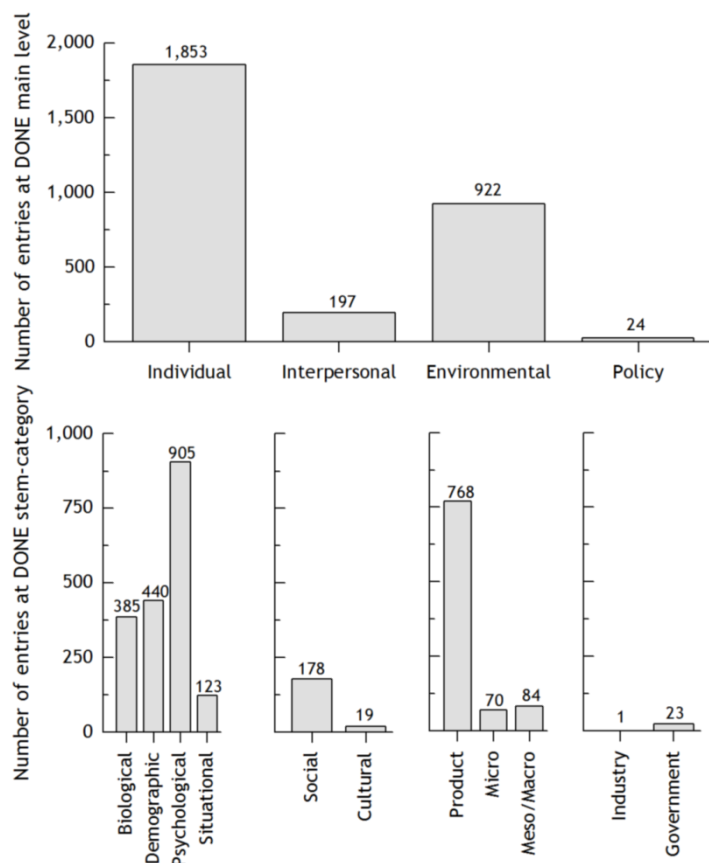


Fig. 4. Number of entries at DONE main level and stem-category (n = 2,996 entries).

The main level predictors were further differentiated with respect to the stem-categories of the DONE framework. As regards individual predictors, psychological factors received the greatest interest (48.8% of the individual predictors), with food beliefs (247) being the most important leaf-category (see Table 2). One fifth of the studies investigate biological factors (20.8%). The relatively large number of anthropometric indicators, brain function, oral function, sleep characteristics, and physical health must be attributed to the fact that medicine/health science emerged as one of the dominant disciplines. Sensory and food-related physiology characteristics, e. g., food preferences and taste sensitivity, constitute vital biological predictors, and the situational predictors include hunger, health-related behavior and situational and time constraints. Demographics (23.7%) also play an important role, presumably

because age, sex or ethnicity as cultural characteristics, and different socioeconomic predictors such as educational level and personal income, are often used as independent or moderating variables.

With regard to environmental predictors, product is the most widely studied factor of food choice (83.3%; see Table 2). This factor can be distinguished into extrinsic product attributes, intrinsic product attributes, and food type. Further predictors are included at the micro-level (e. g., the eating environment), whereas the meso/macro predictors reflect the surroundings of a consumer that (s)he is unable to change, such as food availability and accessibility. The by far smallest stem-category within the DONE framework is the policy predictor with a total of 24 studies.

The analysis shows that there are large differences between well- and under-researched predictors in food research; the median equals 49 (Fig. 5). While 20 of the 39 leaf-category predictors jointly account for 2,611 entries, the remaining 19 predictors jointly sum up to only 385 entries. Among the well-researched predictors are mainly psychological and biological predictors at the individual level, and product characteristics at the environment level. Other environmental predictors and policy-related predictors that may both influence food decision making suffer from a lack of research.

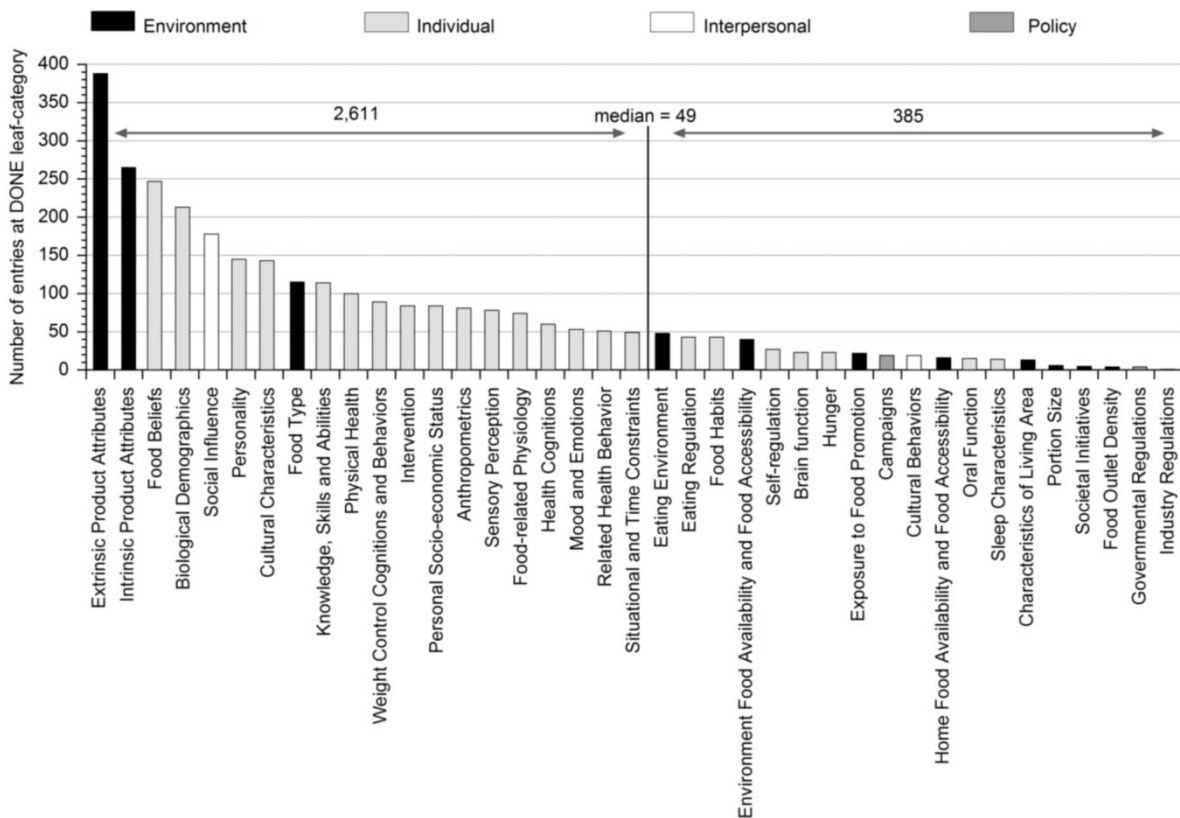


Fig. 5. Number of entries at DONE leaf-category in descending order (n = 2,996 entries).

4.3 Domain-specific predictors (RQ 3)

In almost all disciplines, published research mainly addresses predictors from an individual perspective (Table 3), whereas research in business administration/economics puts emphasis on environmental predictors (highest number of the main level predictors). This can be explained with the fact that widely studied extrinsic product attributes (e. g., price and food labeling) are assigned to the environment level of the DONE framework. In the business literature, purchase intentions are analyzed in the context of food price, manipulated food labels, and other intrinsic or extrinsic cues (Kiesel & Villas-Boas, 2013; Lin, Ver Ploeg, Kasteridis, & Yen, 2014).

The importance of individual predictors at the DONE main level mainly results from the large number of research on biological, psychological, and demographic predictors at the DONE stem-category (see Table 3). In behavioral science, the most examined psychological predictors are weight control cognition and behavior, personality, mood and emotions, and knowledge, skills and abilities. This is also true for psychology and social psychology. Nutritional science and medicine/health science are two of the most active domains working on the examination of almost all predictors of food decision making, but also have a certain focus on psychological predictors.

Table 3. Number of publications at DONE main level and stem-category per discipline.

| Discipline ^a | Individual | | | | | Interpersonal | | | Environment | | | | Policy | | |
|-------------------------|--------------|------------|-------------|---------------|-------------|---------------|--------|----------|-------------|---------|-------|--------------|-----------|------------|----------|
| | Total | Biological | Demographic | Psychological | Situational | Total | Social | Cultural | Total | Product | Micro | Meso / Macro | Total | Government | Industry |
| NS | 1,015 | 200 | 247 | 497 | 71 | 115 | 106 | 9 | 494 | 410 | 42 | 42 | 10 | 10 | 0 |
| MH | 389 | 104 | 119 | 137 | 29 | 47 | 44 | 3 | 153 | 117 | 12 | 24 | 11 | 10 | 1 |
| FT | 435 | 75 | 86 | 262 | 12 | 41 | 36 | 5 | 337 | 298 | 23 | 16 | 1 | 1 | 0 |
| BS | 300 | 54 | 7 | 165 | 21 | 31 | 28 | 16 | 128 | 111 | 13 | 4 | 2 | 2 | 0 |
| B | 264 | 103 | 66 | 66 | 29 | 9 | 9 | 0 | 67 | 51 | 6 | 10 | 4 | 4 | 0 |
| P | 193 | 51 | 15 | 103 | 24 | 10 | 10 | 0 | 55 | 45 | 5 | 5 | 0 | 0 | 0 |
| MC | 97 | 2 | 23 | 68 | 4 | 16 | 14 | 2 | 80 | 71 | 2 | 7 | 1 | 1 | 0 |
| SP | 82 | 9 | 17 | 53 | 3 | 14 | 13 | 1 | 31 | 17 | 5 | 9 | 1 | 1 | 0 |
| BA | 73 | 1 | 19 | 52 | 1 | 12 | 12 | 0 | 89 | 79 | 3 | 7 | 3 | 2 | 1 |
| S | 14 | 0 | 9 | 3 | 2 | 1 | 1 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 |

^aBased on n = 1,820 publications in 485 journals; one to three disciplines could be assigned to one journal. NS, nutritional science; MH, medicine/health science; FT, food science and technology; BS, behavioral science; B, biology; P, psychology; MC, marketing/consumer research; SP, social psychology; BA, business administration/economics; S, sociology. Bold numbers are DONE main level predictors.

Biological predictors, such as food-related physiology and anthropometrics, dominate in biology. In addition, predictors such as physical health, oral function or sleep characteristics are becoming more prevalent. In sociology, research is determined by demographics but, in contrast to other disciplines, the contribution of sociology to analyzing predictors of food choice is small. Business administration/economics, food science and technology, and marketing/consumer research predominantly examine product-related attributes. In total, only three clusters of main research activities across all disciplines were identified, and the domain-specific examination of predictors is limited. All disciplines concentrate on few predictors, whereas the remaining predictors received far less attention in prior research.

4.4 Timeline of publications and research trends (RQ 4)

The earliest publication identified in this study was published in 1954, a book section dealing with food preferences and menu planning. While between 1954 and 1989, the quota was one to eleven publications per year (Table 4), a steady increase in publication number is noticeable since 1990, with currently almost 200 publications per year. Compared to the most recent quinquennium with 883 publications, only 21 of the sampled studies were published between 1980 and 1984. In Web of Science, the ratio of total entries in these two periods is 22.1 million *vs.* 8.8 million, which clearly shows that the topic of food decision making became considerably more important to the research community during the last years.

Table 4. Assignments of publications to disciplines.

| Time period | Number of publications ^a | Assignments of publications to disciplines ^b | | | | | | | | | | |
|--------------|-------------------------------------|---|-----|-----|-----|-----|-----|-----|-----|----|----|--------------|
| | | NS | FT | BS | MH | P | B | MC | BA | SP | S | Total |
| before 1960 | 8 | 1 | 2 | 0 | 0 | 5 | 0 | 1 | 4 | 0 | 0 | 13 |
| 1960 - 1964 | 3 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 |
| 1965 - 1969 | 6 | 0 | 0 | 0 | 2 | 4 | 0 | 1 | 0 | 0 | 0 | 7 |
| 1970 - 1974 | 3 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 4 |
| 1975 - 1979 | 13 | 6 | 2 | 0 | 0 | 5 | 3 | 0 | 0 | 0 | 0 | 16 |
| 1980 - 1984 | 21 | 5 | 1 | 1 | 1 | 9 | 2 | 1 | 0 | 2 | 0 | 22 |
| 1985 - 1989 | 32 | 11 | 2 | 7 | 5 | 8 | 7 | 2 | 1 | 3 | 0 | 46 |
| 1990 - 1994 | 67 | 37 | 2 | 13 | 14 | 14 | 10 | 1 | 4 | 2 | 0 | 97 |
| 1995 - 1999 | 162 | 91 | 12 | 24 | 38 | 26 | 12 | 5 | 7 | 8 | 2 | 225 |
| 2000 - 2004 | 201 | 118 | 26 | 38 | 66 | 20 | 13 | 15 | 14 | 12 | 1 | 323 |
| 2005 - 2009 | 405 | 174 | 86 | 57 | 90 | 44 | 58 | 43 | 22 | 19 | 5 | 598 |
| 2010 - 2014 | 883 | 438 | 172 | 138 | 208 | 103 | 153 | 63 | 56 | 33 | 7 | 1,371 |
| Total | 1,804 | 881 | 307 | 278 | 425 | 242 | 258 | 132 | 108 | 79 | 15 | 2,725 |

^a n = 1,804 publications (1,721 articles in 484 journals and 83 other types of publications, 1954 - 2014)

^b one to three disciplines could be assigned to one journal. NS, nutritional science; FT, food science and technology; BS, behavioral science; MH, medicine/health science; P, psychology; B, biology; MC, marketing/consumer research; BA, business administration/economics; SP, social psychology; S, sociology.

Table 4 also shows the time-based number of publications in the respective research disciplines. Evidently, the increasing trend is mirrored by all disciplines. For half of the disciplines (biology, marketing/consumer research, medicine/health science, nutritional science, and sociology), the research interest peaked in the last quinquennium. Nutritional science started to gain focus in the early 1990s and currently stands for approximately one third of all publications. With a slight delay, research in food science and technology, medicine/health science, behavioral science, biology, and psychology rose gradually, without reaching the amount of nutrition publications. Contrarily, the number of publications in business administration/economics, marketing/consumer research and social psychology remains stable at a relatively low level. Publications dealing with sociological aspects are scarce.

A similar development in the number of publications emerged when distinguishing the levels of the DONE framework over time (Fig. 6). The number of publications on individual predictors exceeds the other predictors at DONE main levels since 1981. With a delay of about 13 years, the number of publications on environmental predictors also started to increase and, since 2004, a continuous increase in publications targeting the interpersonal impact on food choice is evident. Far behind, policy-related publications have been published continuously since 2010 with a small annual number from two to seven publications per year.

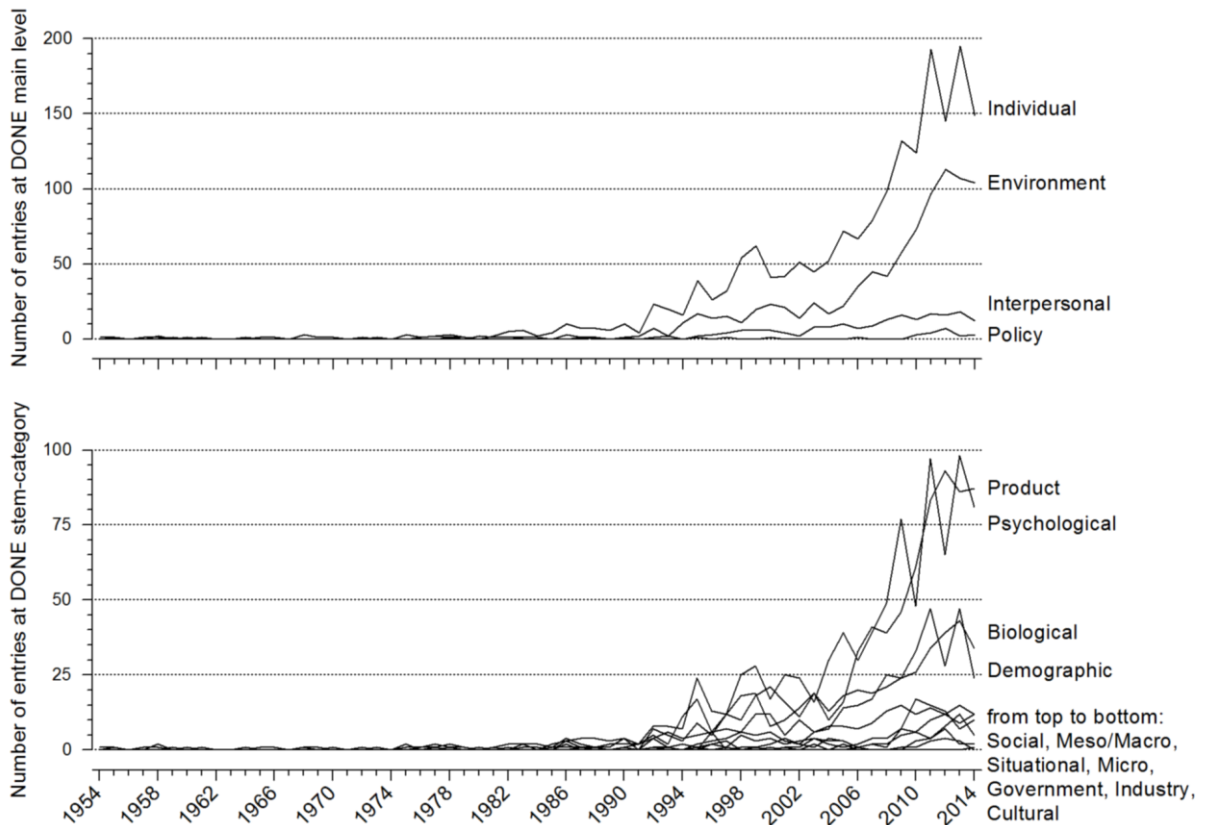


Fig. 6. Timeline of entries at DONE main level and stem-category (1954 - 2014, $n = 2,974$).

The increase in the total number of publications since 1991 is strongly connected to the steady increase of mainly three stem-category predictors of the DONE framework: biological, psychological, and product-related predictors. In accordance with Figure 5, the other predictors hardly attract the interest of the research communities.

5 Interpretation of the findings

This study is the first that systematically reviews quantitative studies in the field of food decision making. The analysis provides new insights into the research topics, the examined predictors of food choice, and current trends. As indicated by the increasing number of publications, the interest in food decision making was continuously growing in the last three decades. Although food decision making is in the scope of many domains, a vast majority of this research is conducted in medicine/health science, and in nutritional science. From a conceptual perspective, biological, psychological, and product-related aspects are hot topics that attract most interest, whereas policy-related factors and other environmental predictors play a less important role in research. In the DONE framework, many researchers attested the policy-related predictors a very high overall research priority (Stok et al., 2016). Yet, according to

the present mapping study, these variables are dramatically under-researched in the field of food decision making.

Researchers may use the results of this study as a state-of-the-art reference and starting point for future projects. It might be helpful to address other predictors to fill some of the identified voids in the research landscape. This overview of past research interests is also important to improve the quality and relevance of new publications, and to avoid unnecessary development expenditures. Given the limited amount of existing research in policy-related and environmental predictors of food decision making, there is much left to explore this topic. Furthermore, undertaking meta-analyses to verify relationships between predictors and food decision making in a quantitative way might be promising.

The categorization of 1,820 different publications into 39 DONE leaf-categories underlines the broad and general applicability of this study. Consequently, practitioners can refer to a broad classification scheme and they may compare the context of a given study with their own situation, therefore ensuring the suitability of the chosen solution. However, practitioners must be aware of the fact that the quality of the considered primary studies differs across the 1,820 studies. So, on the one hand, they have to pay attention to the individual context when referring to a study but, on the other hand, they may contribute to ongoing research by providing new cases for empirical validation.

Limitations must however be mentioned. Firstly, qualitative studies were excluded from the selection process because we primarily focused on determinants suggested in the DONE framework. Secondly, studies on food choice of children or infants were also excluded, and there still may be literature that is not referred to in the databases that were screened with our iterative stepwise approach. Thirdly, we used the journal as a proxy to code the disciplines. Future studies could code previous research efforts according to the discipline of the study itself or according to the affiliation of the authors. This might be helpful to gain new insights into the cross-disciplinary collaboration of researchers.

6 Conclusions

The present study analyzed the field of food decision making research. Out of 10,380 initially identified and screened publications, 1,820 studies (published between 1954 and January 2015) were finally included in this investigation. As a conceptual basis, the DONE framework allowed a systematic and reproducible mapping of the publications. It is the first comprehensive interdisciplinary representation of food research and builds a reference and starting point for further research activities.

The study revealed an ongoing and rising interest in the field of food decision making. The findings have shown which publication channels are used, how the number of publications has changed over time, and which scientific disciplines deal with the food choice process. The study also takes a closer look on which predictors dominate previous research and what current research trends are being explored. Beyond mapping the state-of-the-art, the analysis has discovered several research gaps, such as the lack of quantitative research on the policy-related predictors (e. g., systematic examination of the implications of policy initiatives or specific prevention campaigns for food decision making). Furthermore, implications were derived for further research and practical applications, including the need for more scientific work about the environmental predictors of the DONE framework.

This study provides a systematic approach to guiding research in the field of food decision making. It enables the inclusion of further studies because the DONE framework as a classification scheme can easily be applied to new publications. The field covered in the present study was highly interdisciplinary. This implies that the relevant knowledge on the mechanisms that guide food decision making is spread across publications from very different domains and with several (highly diverse) mental paradigms represented in domain-specific theories, study designs, and data. Therefore, future studies should try to link and integrate the perspectives of the different disciplines to paint a more realistic picture of the food decision making of individuals.

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Web Appendix

Table S1. Complete list of all journals with their number and fractions of articles, and assigned disciplines

| Journal | Number | Fraction (%) | Discipline I | Discipline II | Discipline III |
|---|---------------|---------------------|---------------------|----------------------|-----------------------|
| Acta Agriculturae Scandinavica: Section C, Food Economics | 2 | 0,12 | BA | FT | |
| Acta Comportamentalia | 1 | 0,06 | P | | |
| Acta Neurologica Scandinavica | 1 | 0,06 | MH | | |
| Acta Psychologica | 2 | 0,12 | P | | |
| Acta Scientiarum Polonorum. Technologia Alimentaria | 1 | 0,06 | FT | NS | |
| Addiction | 2 | 0,12 | MH | P | |
| Addictive Behaviors | 3 | 0,17 | MH | | |
| Advances in Consumer Research | 2 | 0,12 | MC | | |
| African Journal of Food, Agriculture, Nutrition and Development | 1 | 0,06 | FT | NS | BA |
| Age and Ageing | 1 | 0,06 | B | | |
| Agribusiness | 4 | 0,23 | FT | BA | |
| Agricultural and Resource Economics Review | 2 | 0,12 | FT | BA | |
| Agricultural Economics Review | 1 | 0,06 | FT | BA | |
| Agricultural Economics-Zemledelska Ekonomika | 4 | 0,23 | FT | BA | |
| Agriculture and Human Values | 3 | 0,17 | FT | BA | |
| Agroalimentaria | 1 | 0,06 | FT | | |
| Alcoholism: Clinical and Experimental Research | 4 | 0,23 | MH | | |
| American Anthropologist | 1 | 0,06 | B | | |
| American Economic Journal: Economic Policy | 1 | 0,06 | BA | | |
| American Journal of Agricultural Economics | 4 | 0,23 | BA | FT | |
| American Journal of Clinical Nutrition | 25 | 1,44 | NS | | |
| American Journal of Health Behavior | 3 | 0,17 | MH | | |
| American Journal of Health Education | 1 | 0,06 | MH | | |
| American Journal of Health Promotion | 7 | 0,40 | MH | | |
| American Journal of Human Biology | 1 | 0,06 | B | | |
| American Journal of Men's Health | 1 | 0,06 | MH | | |
| American Journal of Physiology | 1 | 0,06 | B | | |
| American Journal of Preventive Medicine | 10 | 0,58 | MH | | |
| American Journal of Psychology | 1 | 0,06 | P | | |
| American Journal of Public Health | 8 | 0,46 | MH | | |
| American Journal on Mental Retardation | 2 | 0,12 | MH | | |
| Amyotrophic Lateral Sclerosis and Frontotemporal Degeneration | 1 | 0,06 | MH | | |
| Anales de Psiquiatria | 1 | 0,06 | P | | |
| Annals of Behavioral Medicine | 4 | 0,23 | MH | BS | |
| Annals of Clinical Psychiatry | 1 | 0,06 | P | MH | |
| Annals of Nutrition and Metabolism | 17 | 0,98 | B | NS | |
| Annals of the New York Academy of Sciences | 2 | 0,12 | P | MH | B |
| Anthropologischer Anzeiger | 2 | 0,12 | B | | |

| Journal | Number | Fraction (%) | Discipline I | Discipline II | Discipline III |
|--|---------------|---------------------|---------------------|----------------------|-----------------------|
| Appetite | 224 | 12,90 | BS | NS | |
| Applied Economics | 1 | 0,06 | BA | | |
| Applied Geography | 2 | 0,12 | FT | | |
| Archives of General Psychiatry | 2 | 0,12 | P | | |
| Archives of Internal Medicine | 1 | 0,06 | MH | | |
| Archivos Latinoamericanos De Nutricion | 1 | 0,06 | NS | | |
| Arctic | 1 | 0,06 | BS | NS | |
| Asia Pacific Allergy | 1 | 0,06 | MH | B | |
| Asia Pacific Journal of Clinical Nutrition | 6 | 0,35 | NS | | |
| Atencion Primaria | 1 | 0,06 | MH | | |
| Australasian Medical Journal | 1 | 0,06 | MH | | |
| Australian and New Zealand Journal of Public Health | 5 | 0,29 | MH | | |
| Australian Journal of Agricultural and Resource Economics | 1 | 0,06 | FT | | |
| Australian Journal of Grape and Wine Research | 1 | 0,06 | FT | | |
| Australian Journal of Nutrition and Dietetics | 3 | 0,17 | NS | | |
| Bariatric Nursing and Surgical Patient Care | 1 | 0,06 | MH | | |
| Basic and Applied Social Psychology | 1 | 0,06 | SP | | |
| Behavior Genetics | 1 | 0,06 | P | | |
| Behavior Modification | 1 | 0,06 | P | | |
| Behavioral Medicine | 2 | 0,12 | NS | MH | |
| Behaviormetrika | 1 | 0,06 | BS | | |
| Behaviour Research and Therapy | 2 | 0,12 | P | | |
| Biological Psychiatry | 1 | 0,06 | P | | |
| BMC Pregnancy and Childbirth | 1 | 0,06 | MH | | |
| BMC Psychiatry | 2 | 0,12 | P | | |
| BMC Public Health | 5 | 0,29 | MH | | |
| BMJ: British Medical Journal | 2 | 0,12 | MH | | |
| Brain and Development | 1 | 0,06 | MH | | |
| British Dental Journal | 1 | 0,06 | MH | | |
| British Food Journal | 24 | 1,38 | FT | | |
| British Journal of Health Psychology | 3 | 0,17 | P | | |
| British Journal of Nutrition | 14 | 0,81 | NS | | |
| British Journal of Projective Psychology and Personality Study | 1 | 0,06 | P | | |
| British Journal of Psychiatry | 1 | 0,06 | B | | |
| British Journal of Social Psychology | 4 | 0,23 | SP | | |
| Bulletin of the Psychonomic Society | 1 | 0,06 | P | | |
| Bulletin of Tokyo Dental College | 1 | 0,06 | MH | | |
| Cag University Journal of Social Sciences | 1 | 0,06 | S | BS | |
| Canadian Journal of Agricultural Economics | 3 | 0,17 | BA | | |
| Canadian Journal of Dietetic Practice and Research | 5 | 0,29 | NS | | |
| Canadian Journal of Public Health | 1 | 0,06 | MH | | |

| Journal | Number | Fraction (%) | Discipline I | Discipline II | Discipline III |
|---|--------|--------------|--------------|---------------|----------------|
| Cancer Causes and Control | 1 | 0,06 | MH | | |
| Cardiovascular Diabetology | 1 | 0,06 | MH | B | |
| Chemical Senses | 8 | 0,46 | BS | FT | B |
| Chemosensory Perception | 2 | 0,12 | FT | P | |
| China Agricultural Economic Review | 1 | 0,06 | FT | | |
| Choices: The Magazine of Food, Farm and Resource Issues | 1 | 0,06 | FT | BA | |
| Ciencia and Saude Coletiva | 2 | 0,12 | MH | NS | B |
| Circulation | 3 | 0,17 | MH | | |
| Civilization | 1 | 0,06 | S | | |
| Cleft Palate-Craniofacial Journal | 1 | 0,06 | MH | | |
| Clinical Endocrinology | 1 | 0,06 | B | | |
| Clinical Nutrition | 3 | 0,17 | NS | | |
| Clinical Oral Implants Research | 1 | 0,06 | MH | | |
| Clinical Practice | 1 | 0,06 | MH | | |
| College Student Journal | 4 | 0,23 | MH | S | |
| Collegian | 1 | 0,06 | MH | | |
| Collegium Antropologicum | 1 | 0,06 | B | | |
| Community Dentistry and Oral Epidemiology | 1 | 0,06 | MH | | |
| Comprehensive Psychiatry | 1 | 0,06 | P | | |
| Cornell Hospitality Quarterly | 1 | 0,06 | MC | | |
| Corporate Communications | 1 | 0,06 | MC | | |
| Critical Public Health | 1 | 0,06 | MH | | |
| CTS: Clinical and Translational Science | 1 | 0,06 | MH | | |
| Current Nutrition and Food Science | 1 | 0,06 | FT | NS | |
| Dementia and Geriatric Cognitive Disorders | 2 | 0,12 | B | MH | P |
| Diabetes | 5 | 0,29 | B | | |
| Diabetes Care | 1 | 0,06 | B | | |
| Diabetes Educator | 3 | 0,17 | B | | |
| Diabetes Research and Clinical Practice | 1 | 0,06 | B | | |
| Diabetes/Metabolism Research and Reviews | 1 | 0,06 | B | | |
| Diabetic Medicine | 1 | 0,06 | B | | |
| Diabetologia | 2 | 0,12 | B | | |
| Digestive and Liver Disease | 2 | 0,12 | MH | | |
| Dirasat: Administrative Sciences | 1 | 0,06 | MC | BA | |
| Disability and Health Journal | 1 | 0,06 | MH | | |
| Diseases of the Colon and Rectum | 1 | 0,06 | MH | | |
| Drug Development Research | 1 | 0,06 | MH | | |
| Dysphagia | 1 | 0,06 | MH | | |
| East African Journal of Public Health | 1 | 0,06 | MH | | |
| Eating and Weight Disorders | 3 | 0,17 | P | | |
| Eating Behaviors | 8 | 0,46 | P | NS | |
| Eating Disorders | 1 | 0,06 | BS | MH | NS |
| Eating Disorders Review | 2 | 0,12 | BS | MH | NS |

| Journal | Number | Fraction (%) | Discipline I | Discipline II | Discipline III |
|---|---------------|---------------------|---------------------|----------------------|-----------------------|
| Ecological Economics | 1 | 0,06 | BS | P | BA |
| Ecology of Food and Nutrition | 6 | 0,35 | NS | | |
| Economic Inquiry | 1 | 0,06 | BA | | |
| Economies et Societes | 1 | 0,06 | BA | | |
| Endocrine | 1 | 0,06 | B | | |
| Endocrine Reviews | 1 | 0,06 | B | | |
| Endocrinologia y Nutricion | 1 | 0,06 | B | | |
| Environment and Behavior | 1 | 0,06 | BS | P | |
| Environmental Research | 1 | 0,06 | BS | MH | |
| Ernahrungs-Umschau | 1 | 0,06 | NS | | |
| Estudios Sociales | 2 | 0,12 | SP | | |
| Ethnicity and Disease | 2 | 0,12 | MH | | |
| European Eating Disorders Review | 3 | 0,17 | P | NS | |
| European Heart Journal | 1 | 0,06 | MH | | |
| European Journal of Cancer Care | 1 | 0,06 | MH | | |
| European Journal of Cardiovascular Nursing | 1 | 0,06 | MH | | |
| European Journal of Clinical Nutrition | 16 | 0,92 | NS | | |
| European Journal of Epidemiology | 1 | 0,06 | MH | | |
| European Journal of Marketing | 2 | 0,12 | MC | | |
| European Journal of Nutrition | 2 | 0,12 | NS | | |
| European Journal of Personality | 1 | 0,06 | SP | | |
| European Journal of Public Health | 4 | 0,23 | MH | | |
| European Journal of Social Psychology | 3 | 0,17 | SP | | |
| European Psychiatry | 2 | 0,12 | P | | |
| European Review of Agricultural Economics | 3 | 0,17 | BA | | |
| Experimental Psychology | 1 | 0,06 | P | | |
| Family and Consumer Sciences Research Journal | 4 | 0,23 | S | BS | NS |
| Family Economics and Nutrition Review | 1 | 0,06 | SP | MH | |
| Family Practice | 1 | 0,06 | SP | MH | |
| FASEB Journal | 31 | 1,78 | B | | |
| Food and Function | 1 | 0,06 | FT | B | |
| Food and Nutrition Research | 4 | 0,23 | FT | NS | |
| Food Control | 2 | 0,12 | FT | | |
| Food Policy | 19 | 1,09 | FT | NS | |
| Food Quality and Preference | 113 | 6,51 | FT | NS | |
| Food Research International | 4 | 0,23 | FT | NS | |
| Food Science and Technology International | 1 | 0,06 | FT | BA | MH |
| Food Service Technology | 2 | 0,12 | FT | BA | MH |
| FoodReview | 1 | 0,06 | FT | BA | |
| Forum of Nutrition | 1 | 0,06 | NS | | |
| Frontiers in Behavioral Neuroscience | 1 | 0,06 | BS | P | |
| Frontiers in Neuroscience | 1 | 0,06 | BS | P | |
| Frontiers in Psychology | 3 | 0,17 | P | | |
| Genes and Nutrition | 2 | 0,12 | B | NS | |

| Journal | Number | Fraction (%) | Discipline I | Discipline II | Discipline III |
|---|---------------|---------------------|---------------------|----------------------|-----------------------|
| Genetika-Belgrade | 1 | 0,06 | B | | |
| Group Processes and Intergroup Relations | 1 | 0,06 | SP | | |
| Health Affairs | 3 | 0,17 | MH | | |
| Health and Place | 2 | 0,12 | MH | | |
| Health Economics | 3 | 0,17 | BA | MH | |
| Health Education and Behavior | 3 | 0,17 | MH | | |
| Health Education Journal | 3 | 0,17 | SP | MH | |
| Health Education Research | 3 | 0,17 | SP | MH | |
| Health Marketing Quarterly | 2 | 0,12 | MC | | |
| Health Promotion International | 2 | 0,12 | MH | | |
| Health Promotion Journal of Australia | 1 | 0,06 | MH | | |
| Health Promotion Practice | 3 | 0,17 | MH | | |
| Health Psychology | 10 | 0,58 | P | | |
| Health SA Gesundheit | 1 | 0,06 | MH | | |
| Home Health Care Management and Practice | 1 | 0,06 | MH | | |
| Homeostasis in Health and Disease | 1 | 0,06 | B | MH | P |
| Howard Journal of Communications | 1 | 0,06 | MC | BA | BS |
| Human and Ecological Risk Assessment | 1 | 0,06 | BS | | |
| Human Factors | 1 | 0,06 | MH | P | |
| Human Physiology | 1 | 0,06 | B | MH | |
| Hungarian Journal of Psychology | 1 | 0,06 | P | | |
| Indian Journal of Behaviour | 1 | 0,06 | BS | | |
| Indian Journal of Endocrinology and Metabolism | 1 | 0,06 | B | MH | |
| Indian Journal of Gerontology | 1 | 0,06 | NS | | |
| International Dairy Journal | 1 | 0,06 | FT | | |
| International Food and Agribusiness Management Review | 1 | 0,06 | FT | | |
| International Journal of Behavioral Medicine | 2 | 0,12 | P | | |
| International Journal of Behavioral Nutrition and Physical Activity | 16 | 0,92 | NS | B | |
| International Journal of Business Insights and Transformation | 1 | 0,06 | MC | BA | |
| International Journal of Cardiology | 1 | 0,06 | MH | | |
| International Journal of Circumpolar Health | 2 | 0,12 | MH | | |
| International Journal of Consumer Studies | 23 | 1,32 | MC | | |
| International Journal of Contemporary Hospitality Management | 3 | 0,17 | BA | MC | |
| International Journal of Eating Disorders | 11 | 0,63 | P | | |
| International Journal of Endocrinology | 1 | 0,06 | B | | |
| International Journal of Environmental Research and Public Health | 1 | 0,06 | MH | | |
| International Journal of Food Sciences and Nutrition | 2 | 0,12 | FT | NS | |
| International Journal of Geriatric Psychiatry | 1 | 0,06 | B | P | |
| International Journal of Health Geographics | 1 | 0,06 | B | NS | |

| Journal | Number | Fraction (%) | Discipline I | Discipline II | Discipline III |
|--|---------------|---------------------|---------------------|----------------------|-----------------------|
| International Journal of Hospitality and Tourism Administration | 2 | 0,12 | MH | BA | |
| International Journal of Hospitality Management | 5 | 0,29 | MH | | |
| International Journal of Industrial Organization | 1 | 0,06 | BA | | |
| International Journal of Management Cases | 1 | 0,06 | BA | | |
| International Journal of Obesity | 10 | 0,58 | B | NS | |
| International Journal of Obesity and Related Metabolic Disorders | 2 | 0,12 | B | NS | |
| International Journal of Prosthodontics | 2 | 0,12 | MH | | |
| International Journal of Psychiatry in Medicine | 1 | 0,06 | P | | |
| International Journal of Psychology | 2 | 0,12 | P | | |
| International Journal of Research in Commerce and Management | 1 | 0,06 | MC | | |
| International Journal of Research in Marketing | 2 | 0,12 | MC | | |
| International Journal of Sport Nutrition | 1 | 0,06 | NS | | |
| International Journal of Sport Nutrition and Exercise Metabolism | 2 | 0,12 | NS | B | |
| Italian Journal of Food Science | 1 | 0,06 | FT | | |
| Japanese Journal of Behaviormetrics | 1 | 0,06 | P | | |
| Japanese Journal of Health Psychology | 2 | 0,12 | P | | |
| Jornal Brasileiro de Psiquiatria | 3 | 0,17 | MH | P | |
| Journal für Verbraucherschutz und Lebensmittelsicherheit | 1 | 0,06 | FT | | |
| Journal of Adolescent Health | 2 | 0,12 | MH | | |
| Journal of Agribusiness in Developing and Emerging Economies | 1 | 0,06 | FT | BA | |
| Journal of Agricultural and Applied Economics | 1 | 0,06 | FT | BA | |
| Journal of Agricultural and Food Industrial Organization | 1 | 0,06 | FT | BA | |
| Journal of Agricultural Economics | 2 | 0,12 | FT | BA | |
| Journal of Allergy and Clinical Immunology | 1 | 0,06 | B | MH | |
| Journal of Alternative and Complementary Medicine | 1 | 0,06 | MH | | |
| Journal of American College Health | 4 | 0,23 | SP | MH | |
| Journal of Applied Behavior Analysis | 3 | 0,17 | P | | |
| Journal of Applied Psychology | 5 | 0,29 | P | BA | |
| Journal of Applied Social Psychology | 6 | 0,35 | SP | | |
| Journal of Behavior Therapy and Experimental Psychiatry | 1 | 0,06 | P | | |
| Journal of Biological Regulators and Homeostatic Agents | 1 | 0,06 | B | MH | |
| Journal of Biosocial Science | 1 | 0,06 | MH | NS | |
| Journal of Business and Retail Management Research | 1 | 0,06 | MC | | |
| Journal of Business Research | 4 | 0,23 | MC | | |
| Journal of Cancer Education | 1 | 0,06 | MH | SP | |
| Journal of Cardiopulmonary Rehabilitation and Prevention | 1 | 0,06 | MH | | |

| Journal | Number | Fraction (%) | Discipline I | Discipline II | Discipline III |
|--|---------------|---------------------|---------------------|----------------------|-----------------------|
| Journal of Chiropractic Education | 1 | 0,06 | SP | MH | |
| Journal of Clinical Lipidology | 1 | 0,06 | MH | | |
| Journal of Clinical Nursing | 1 | 0,06 | MH | | |
| Journal of Clinical Psychiatry | 1 | 0,06 | P | | |
| Journal of Cognitive Neuroscience | 1 | 0,06 | P | | |
| Journal of Collaborative Research on Internal Medicine and Public Health | 1 | 0,06 | MH | | |
| Journal of Community and Applied Social Psychology | 1 | 0,06 | SP | | |
| Journal of Community Health | 1 | 0,06 | MH | | |
| Journal of Consulting and Clinical Psychology | 1 | 0,06 | MH | P | |
| Journal of Consumer Affairs | 4 | 0,23 | MC | BA | |
| Journal of Consumer Behaviour | 3 | 0,17 | MC | BA | |
| Journal of Consumer Marketing | 1 | 0,06 | MC | | |
| Journal of Consumer Policy | 1 | 0,06 | MC | BA | BS |
| Journal of Consumer Psychology | 2 | 0,12 | MC | P | |
| Journal of Consumer Research | 12 | 0,69 | MC | | |
| Journal of Consumer Studies and Home Economics | 4 | 0,23 | MC | BA | |
| Journal of Counseling Psychology | 1 | 0,06 | P | | |
| Journal of Culinary Science and Technology | 3 | 0,17 | FT | | |
| Journal of Dairy Science | 3 | 0,17 | FT | | |
| Journal of Dental Research | 1 | 0,06 | MH | | |
| Journal of Dentistry | 1 | 0,06 | MH | | |
| Journal of Diabetes | 5 | 0,29 | B | | |
| Journal of Diabetes Nursing | 1 | 0,06 | MH | | |
| Journal of Economic Behavior and Organization | 1 | 0,06 | BA | | |
| Journal of Economic Psychology | 2 | 0,12 | BA | | |
| Journal of Environmental and Public Health | 1 | 0,06 | MH | | |
| Journal of Environmental Psychology | 1 | 0,06 | P | | |
| Journal of Epidemiology | 2 | 0,12 | MH | | |
| Journal of Epidemiology and Community Health | 3 | 0,17 | MH | | |
| Journal of Experimental Psychology: Applied | 1 | 0,06 | P | | |
| Journal of Experimental Social Psychology | 2 | 0,12 | SP | | |
| Journal of Food Agriculture and Environment | 1 | 0,06 | FT | BS | |
| Journal of Food Distribution Research | 4 | 0,23 | FT | MC | BA |
| Journal of Food Products Marketing | 6 | 0,35 | FT | MC | |
| Journal of Food Quality | 1 | 0,06 | FT | NS | |
| Journal of Food Research | 1 | 0,06 | FT | NS | |
| Journal of Food Science | 14 | 0,81 | FT | | |
| Journal of Foodservice | 1 | 0,06 | FT | | |
| Journal of Foodservice Business Research | 7 | 0,40 | FT | BA | |
| Journal of Gastrointestinal Surgery | 1 | 0,06 | MH | | |
| Journal of General Internal Medicine | 5 | 0,29 | MH | | |
| Journal of General Medicine | 1 | 0,06 | MH | S | |

| Journal | Number | Fraction (%) | Discipline I | Discipline II | Discipline III |
|--|---------------|---------------------|---------------------|----------------------|-----------------------|
| Journal of Gerontology | 2 | 0,12 | B | | |
| Journal of Health Care for the Poor and Underserved | 1 | 0,06 | MH | | |
| Journal of Health Communication | 2 | 0,12 | MC | | |
| Journal of Health Education | 1 | 0,06 | MH | | |
| Journal of Health Psychology | 2 | 0,12 | P | | |
| Journal of Homosexuality | 1 | 0,06 | P | BS | |
| Journal of Hospitality and Leisure Marketing | 1 | 0,06 | MC | | |
| Journal of Human Nutrition and Dietetics | 23 | 1,32 | NS | | |
| Journal of Intellectual Disability Research | 2 | 0,12 | SP | MH | |
| Journal of Internal Medicine | 1 | 0,06 | MH | | |
| Journal of International Food and Agribusiness Marketing | 8 | 0,46 | NS | BA | MC |
| Journal of Investigative Medicine | 2 | 0,12 | MH | | |
| Journal of Kidney Diseases | 1 | 0,06 | MH | | |
| Journal of Macromarketing | 1 | 0,06 | MC | | |
| Journal of Marketing | 3 | 0,17 | MC | | |
| Journal of Marketing Management | 2 | 0,12 | MC | | |
| Journal of Marketing Research | 1 | 0,06 | MC | | |
| Journal of Medical Science | 1 | 0,06 | MH | | |
| Journal of Medicinal Food | 1 | 0,06 | MH | FT | NS |
| Journal of Mental Deficiency Research | 2 | 0,12 | MH | | |
| Journal of Nervous and Mental Disease | 1 | 0,06 | P | MH | |
| Journal of Neurology, Neurosurgery and Psychiatry | 1 | 0,06 | MH | P | |
| Journal of Neuroscience | 1 | 0,06 | P | | |
| Journal of Nonprofit and Public Sector Marketing | 1 | 0,06 | MC | | |
| Journal of Nutrigenetics and Nutrigenomics | 2 | 0,12 | B | NS | |
| Journal of Nutrition | 4 | 0,23 | NS | | |
| Journal of Nutrition Education | 16 | 0,92 | NS | | |
| Journal of Nutrition Education and Behavior | 28 | 1,61 | SP | NS | |
| Journal of Nutrition for the Elderly | 8 | 0,46 | NS | B | |
| Journal of Nutrition in Gerontology and Geriatrics | 2 | 0,12 | NS | B | |
| Journal of Nutrition, Health and Aging | 6 | 0,35 | B | NS | |
| Journal of Obesity | 2 | 0,12 | MH | | |
| Journal of Oral Rehabilitation | 1 | 0,06 | MH | | |
| Journal of Pain and Symptom Management | 1 | 0,06 | MH | | |
| Journal of Personality and Clinical Studies | 1 | 0,06 | P | MH | |
| Journal of Pharmacology | 1 | 0,06 | MH | | |
| Journal of Physical Anthropology | 1 | 0,06 | B | | |
| Journal of Physiology and Pharmacology | 1 | 0,06 | B | | |
| Journal of Policy Modeling | 1 | 0,06 | BA | | |
| Journal of Prosthetic Dentistry | 2 | 0,12 | MH | | |
| Journal of Psychiatric Practice | 1 | 0,06 | P | | |

| Journal | Number | Fraction (%) | Discipline I | Discipline II | Discipline III |
|---|---------------|---------------------|---------------------|----------------------|-----------------------|
| Journal of Psychiatric Research | 2 | 0,12 | P | | |
| Journal of Psychology | 5 | 0,29 | P | | |
| Journal of Psychosomatic Research | 1 | 0,06 | P | | |
| Journal of Public Health | 1 | 0,06 | MH | | |
| Journal of Public Policy and Marketing | 3 | 0,17 | MC | | |
| Journal of Quality Assurance in Hospitality and Tourism | 1 | 0,06 | MC | | |
| Journal of Renal Nutrition | 2 | 0,12 | NS | MH | |
| Journal of Research in Personality | 1 | 0,06 | SP | | |
| Journal of Retailing and Consumer Services | 1 | 0,06 | MC | | |
| Journal of Sensory Studies | 21 | 1,21 | FT | | |
| Journal of Sleep Research | 1 | 0,06 | MH | P | |
| Journal of Social and Clinical Psychology | 1 | 0,06 | P | | |
| Journal of Social Psychology | 2 | 0,12 | SP | | |
| Journal of Sports Sciences | 1 | 0,06 | B | | |
| Journal of Tekirdag Agricultural Faculty | 1 | 0,06 | FT | | |
| Journal of the Academy of Marketing Science | 1 | 0,06 | MC | | |
| Journal of the Academy of Nutrition and Dietetics | 22 | 1,27 | NS | | |
| Journal of the American College of Nutrition | 3 | 0,17 | NS | | |
| Journal of the American Dietetic Association | 79 | 4,55 | NS | | |
| Journal of the American Pharmacists Association | 1 | 0,06 | MH | | |
| Journal of the Experimental Analysis of Behavior | 1 | 0,06 | BS | | |
| Journal of the Japanese Society for Food Science and Technology | 1 | 0,06 | FT | | |
| Journal of the Market Research Society | 1 | 0,06 | MC | | |
| Journal of the National Medical Association | 2 | 0,12 | MH | | |
| Journal of the Science of Food and Agriculture | 2 | 0,12 | FT | | |
| Journal of Transplantation | 1 | 0,06 | MH | | |
| Journal of Women's Health | 2 | 0,12 | MH | B | |
| Journal of Wound, Ostomy and Continence Nursing | 1 | 0,06 | MH | | |
| Judgment and Decision Making | 3 | 0,17 | P | MC | |
| Korean Nurse | 1 | 0,06 | MH | | |
| Land Use Policy | 1 | 0,06 | BS | | |
| Learning and Motivation | 1 | 0,06 | P | | |
| Liver Transplantation | 1 | 0,06 | MH | | |
| Local Environment | 2 | 0,12 | FT | BA | |
| LWT - Food Science and Technology | 2 | 0,12 | FT | | |
| Marketing Intelligence and Planning | 1 | 0,06 | MC | | |
| Marketing Letters | 1 | 0,06 | MC | P | |
| Marketing Management Journal | 1 | 0,06 | MC | | |
| Maternal and Child Nutrition | 1 | 0,06 | NS | MH | |
| Meat Science | 1 | 0,06 | FT | | |
| Media Psychology | 1 | 0,06 | MC | P | |

| Journal | Number | Fraction (%) | Discipline I | Discipline II | Discipline III |
|---|---------------|---------------------|---------------------|----------------------|-----------------------|
| Medical Channel | 1 | 0,06 | MH | | |
| Medical Hypotheses | 1 | 0,06 | MH | | |
| Menopause | 2 | 0,12 | MH | | |
| Military Medicine | 2 | 0,12 | MH | | |
| Mljekarstvo - Dairy | 1 | 0,06 | MC | MH | FT |
| Molecular and Cellular Endocrinology | 1 | 0,06 | B | MH | |
| Molecular Metabolism | 1 | 0,06 | B | MH | |
| Molecular Psychiatry | 1 | 0,06 | B | P | |
| Movement Disorders | 1 | 0,06 | MH | | |
| National Health Statistics Reports | 1 | 0,06 | MH | NS | |
| Neurocase | 1 | 0,06 | MH | P | |
| NeuroImage | 2 | 0,12 | P | MH | |
| Neurology | 1 | 0,06 | P | MH | |
| Neuropsychopharmacology | 1 | 0,06 | P | MH | |
| NeuroReport: For Rapid Communication of Neuroscience Research | 1 | 0,06 | P | | |
| Neuroscience | 1 | 0,06 | P | | |
| Neuroscience and Biobehavioral Reviews | 2 | 0,12 | P | BS | |
| North American Journal of Psychology | 1 | 0,06 | P | BS | |
| Nursing Standard | 1 | 0,06 | MH | | |
| Nutricion Hospitalaria | 8 | 0,46 | NS | | |
| Nutridate | 1 | 0,06 | MH | | |
| Nutrients | 3 | 0,17 | NS | | |
| Nutrition and Behavior | 1 | 0,06 | NS | BS | |
| Nutrition and Cancer | 2 | 0,12 | MH | NS | |
| Nutrition and Diabetes | 1 | 0,06 | NS | MH | |
| Nutrition and Dietetics | 3 | 0,17 | NS | | |
| Nutrition and Food Science | 2 | 0,12 | NS | FT | |
| Nutrition and Health | 1 | 0,06 | MH | NS | |
| Nutrition and Metabolism | 1 | 0,06 | NS | B | |
| Nutrition Bulletin | 3 | 0,17 | NS | | |
| Nutrition Journal | 9 | 0,52 | NS | | |
| Nutrition Research | 12 | 0,69 | NS | | |
| Nutrition Research and Practice | 3 | 0,17 | NS | | |
| Nutrition Reviews | 1 | 0,06 | NS | | |
| Nutrition, Metabolism, and Cardiovascular Diseases | 1 | 0,06 | NS | B | MH |
| Nutritional Neuroscience | 1 | 0,06 | P | NS | |
| Nutritional Sciences Journal | 1 | 0,06 | NS | MH | |
| Obesity | 13 | 0,75 | B | NS | |
| Obesity Facts | 9 | 0,52 | B | NS | |
| Obesity Research | 1 | 0,06 | B | NS | |
| Obesity Reviews | 6 | 0,35 | B | NS | |
| Obesity Surgery | 4 | 0,23 | B | MH | |
| Occupational Medicine | 1 | 0,06 | MH | | |

| Journal | Number | Fraction (%) | Discipline I | Discipline II | Discipline III |
|---|--------|--------------|--------------|---------------|----------------|
| Oncology Nursing Forum | 1 | 0,06 | MH | | |
| Otolaryngology - Head and Neck Surgery | 1 | 0,06 | MH | | |
| Pacific Health Dialog | 1 | 0,06 | MH | | |
| Pain Medicine | 1 | 0,06 | MH | | |
| Pan American Journal of Public Health | 1 | 0,06 | MH | | |
| Patient Education and Counseling | 2 | 0,12 | SP | | |
| Pediatric Diabetes | 1 | 0,06 | B | MH | |
| Perceptual and Motor Skills | 3 | 0,17 | P | | |
| Personality and Individual Differences | 3 | 0,17 | SP | | |
| Perspectives in Public Health | 2 | 0,12 | MH | | |
| Pharmacotherapy | 1 | 0,06 | MH | | |
| Physiology and Behavior | 30 | 1,73 | B | P | |
| PLoS ONE | 11 | 0,63 | BS | B | MH |
| Polish Journal of Food and Nutrition Sciences | 1 | 0,06 | FT | NS | |
| Preventing Chronic Disease | 2 | 0,12 | MH | | |
| Preventive Medicine | 10 | 0,58 | MH | | |
| Progress in Cardiovascular Nursing | 1 | 0,06 | MH | | |
| Psychiatria i Psychologia Kliniczna | 1 | 0,06 | MH | P | |
| Psychiatry Research | 1 | 0,06 | P | | |
| Psycho-Oncology | 1 | 0,06 | P | | |
| Psychological Record | 1 | 0,06 | P | | |
| Psychological Reports | 3 | 0,17 | P | | |
| Psychological Review | 2 | 0,12 | P | | |
| Psychological Science | 2 | 0,12 | P | BA | |
| Psychological Studies | 1 | 0,06 | P | MH | |
| Psychology and Health | 7 | 0,40 | MC | P | |
| Psychology and Marketing | 5 | 0,29 | MH | P | |
| Psychology of Addictive Behaviors | 1 | 0,06 | MH | P | |
| Psychology, Health and Medicine | 1 | 0,06 | B | P | |
| Psychoneuroendocrinology | 2 | 0,12 | MH | P | |
| Psychopharmacology | 5 | 0,29 | P | MH | |
| Psychophysiology | 1 | 0,06 | P | B | |
| Psychosomatic Medicine | 2 | 0,12 | P | | |
| Public Health | 2 | 0,12 | MH | | |
| Public Health Nutrition | 50 | 2,88 | MH | NS | |
| Quarterly Journal of Studies on Alcohol | 1 | 0,06 | MH | | |
| Regional Anesthesia and Pain Medicine | 1 | 0,06 | MH | | |
| Registered Nurse Journal | 1 | 0,06 | MH | | |
| Rehabilitation Nursing | 1 | 0,06 | MH | | |
| Renewable Agriculture and Food Systems | 1 | 0,06 | FT | | |
| Reproductive Sciences | 1 | 0,06 | MH | B | |
| Review of Agricultural Economics | 1 | 0,06 | BA | | |
| Revista de la Facultad de Ciencias Medicas | 2 | 0,12 | MH | | |
| Revista Espanola De Nutricion Comunitaria | 1 | 0,06 | NS | | |

| Journal | Number | Fraction (%) | Discipline I | Discipline II | Discipline III |
|--|--------------|---------------|--------------|---------------|----------------|
| Revue d'Economie Politique | 1 | 0,06 | BA | | |
| Risk Analysis | 2 | 0,12 | MH | BS | |
| Rivista di Economia Agraria | 1 | 0,06 | BA | | |
| Roczniki Panstwowego Zakladu Higieny | 1 | 0,06 | MH | | |
| Rural Sociology | 1 | 0,06 | S | | |
| Salud Publica de Mexico | 2 | 0,12 | MH | | |
| Scandinavian Journal of Food and Nutrition | 1 | 0,06 | FT | MH | |
| Scandinavian Journal of Psychology | 1 | 0,06 | P | | |
| Scandinavian Journal of Public Health | 1 | 0,06 | MH | | |
| Sciences des Aliments | 1 | 0,06 | FT | | |
| Sex Roles | 1 | 0,06 | P | B | |
| Sleep | 2 | 0,12 | MH | P | |
| Sleep and Biological Rhythms | 3 | 0,17 | MH | P | |
| Social Indicators Research | 1 | 0,06 | SP | S | |
| Social Marketing Quarterly | 1 | 0,06 | MC | BA | |
| Social Psychological and Personality Science | 1 | 0,06 | P | | |
| Social Science and Medicine | 4 | 0,23 | MH | BS | |
| Social Sciences in Health | 1 | 0,06 | MH | BS | |
| Soins Pediatrie/Puericulture | 1 | 0,06 | SP | MH | |
| Special Care in Dentistry | 1 | 0,06 | MH | | |
| Sport Journal | 1 | 0,06 | B | | |
| Stress and Health | 1 | 0,06 | P | | |
| Suranaree Journal of Science and Technology | 1 | 0,06 | B | FT | |
| The American Journal of Maternal / Child Nursing | 1 | 0,06 | MH | | |
| The Laryngoscope | 1 | 0,06 | MH | | |
| Topics in Clinical Nutrition | 8 | 0,46 | MH | | |
| Tourism and Hospitality Management | 1 | 0,06 | BA | | |
| Trials | 1 | 0,06 | MH | | |
| Twin Research and Human Genetics | 1 | 0,06 | B | | |
| U.S. Army Medical Department Journal | 1 | 0,06 | MH | | |
| WMJ : Official Publication of the State Medical Society of Wisconsin | 1 | 0,06 | MH | | |
| Young Consumers | 1 | 0,06 | MC | BA | |
| Zeitschrift für Ernährungswissenschaft | 2 | 0,12 | NS | | |
| Total | 1,737 | 100,00 | | | |

NS, nutritional science; MH, medicine/health science; FT, food science and technology; BS, behavioral science; B, biology; P, psychology; MC, marketing/consumer research; SP, social psychology; BA, business administration/economics; S, sociology.

C.2 – Extrinsic and intrinsic food product attributes in consumer and sensory research: Literature review and quantification of the findings

Abstract

As recent years have seen a growing interest in integrating consumer and sensory science, this paper aims at presenting a systematic literature review of empirical studies investigating the effects of intrinsic and extrinsic food product attributes on consumers' food decision making. Both an electronic search through a digital library database and a forward-backward search identified relevant international research. The final set of studies ($n = 602$) was coded in terms of research methods, intrinsic and/or extrinsic product attributes, consumer response measurement, study location, sample size, study origin, and food type. Although the importance of some product attributes such as taste, label, and price are very well recognized, other variables such as appearance, smell, sound, texture, and packaging have been neglected in research so far. Findings also show an imbalance of applied methods in consumer and sensory research. Surveys/questionnaires and acceptance tests are well-represented, whereas other methods or combinations thereof were rarely or never applied. Food liking was found to be the most frequent way to obtain consumer food evaluation data. Mirroring an increasing importance of product attributes in consumer food decisions, marketing managers and product developers today are well advised to take simultaneous effects of extrinsic and product attributes into account. This article calls for future studies with more holistic study designs to avoid the risk of misleading conclusions in both consumer and sensory research.

Keywords

Food decision making, systematic review, intrinsic attributes, extrinsic attributes, consumer research, sensory research

1 Introduction

Today's food market seems to be saturated in almost all food groups, leading to an increased competition among food producers and, in turn, to the need to continuously develop new products (Combris et al. 2009). Strategic marketing, including the development of new businesses, plays an important role in promoting product innovations that are able to attract consumers' attention and to stimulate purchases. However, in the food market, between half and two-thirds of launched products end up failing (Dijksterhuis 2016). Due to market saturation and product variety, the main obstacle for food producers is finding success in the market. To do so, food marketers need to know which product attributes contribute to product success or failure. The aim of this review is to provide an overview of the existing knowledge of extrinsic and intrinsic food product attributes in consumer and sensory research that can be used by food marketers. Additionally, by filling the identified research gaps, the marketing and business practice might gain the potential to find new ways to influence consumer food decisions.

In stores, consumers make rapid choices among multiple products that differ in their extrinsic (e.g., brand, packaging, label, price) and their expected intrinsic attributes (e.g., taste). When purchasing a food for the first time, sensory information is missing and consumers are compelled to rely on *extrinsic food attributes*. Recent studies in marketing and business literature show that consumers form their judgments based on heuristic conclusions about the product's extrinsic attributes in the absence of intrinsic sensory properties (Irmak et al. 2011; Deng and Srinivasan 2013). In post-purchase situations, consumers are able to refer to sensory information without the need to deduce taste from heuristic cues (Mai et al. 2016). Prior research shows that taste judgments mainly build on actual sensory perception of *intrinsic properties*, rather than on expectations formed by extrinsic attributes (e.g., Arvola et al. 1999; Hoegg and Alba 2007). Despite a few studies showing that extrinsic cues may bias actual taste experiences (Wansink and Park 2002; Naylor et al. 2009; Irmak et al. 2011), most of the research focuses either on intrinsic *or* extrinsic food attributes. This raises research question 1:

Research question 1: Which extrinsic and intrinsic product attributes have been analyzed in food decision making research and to what extent?

Research on the impact of product attributes on food decision making originates from different academic disciplines, each using different scientific methods (Grunert 2015). *Business and consumer research* mainly use methods that analyze extrinsic food attributes. The extrinsic attributes are a part of the marketing mix with a focus on the visual sense of

consumers only. In contrast, *sensory research* uses methods that analyze changes in the intrinsic properties of a food based on a variation of the nutritional composition or in the manufacturing process. These changes, in turn, influence all human senses (appearance, taste, smell, sound, texture), regardless of the purchase context (Grunert 2015). What has been neglected in research so far is an overview about which methods are typical for both streams of research and to what extent they are used. Moreover, this article intends to provide an overview of method use over time. This leads to the second research question:

Research question 2: Which methods are typical for consumer and sensory research, to what extent were they used in food decision making research, and how has their use changed over time?

Although several articles have called to integrate consumer and sensory research more thoroughly (Garber et al. 2003; van Kleef et al. 2005; Jaeger 2006; Enneking et al. 2007; Raz et al. 2008; Combris et al. 2009; Simeone and Marotta 2010; Piqueras-Fiszman and Spence 2015), an overview of intrinsic and extrinsic food product attributes in consumer and sensory research is still missing. The third research question therefore aims to combine the findings of research questions 1 and 2:

Research question 3: Which extrinsic and intrinsic product attributes have been investigated? Which methods from consumer and sensory research were used and to what extent?

To answer the research questions, this paper employs a three-tier approach: a) an extensive systematic literature review, based on methodological propositions of Tranfield et al. (2003), produces a comprehensive summary of existing scientific studies about intrinsic and/or extrinsic product attributes; b) this review reveals research methods from consumer and sensory research that have widely been used to predict consumer food decisions; and c) a subsequent quantitative content analysis synthesizes the findings across all included studies using a deductive approach (Kondracki et al. 2002). Finally, a roadmap for further interdisciplinary research is outlined and implications for the business and marketing practice are discussed.

2 Theoretical background

2.1 Extrinsic and intrinsic product attributes

The sources from which consumers form expectations and perceptions of a food product are typically separated into extrinsic and intrinsic product cues. Both of them affect food decisions, but they differ in the point of time in which they occur. Extrinsic product at-

tributes are related to the product but are not physically a part of what is tasted or consumed. Subsequently, consumers make their purchase decisions under uncertainty with regard to product quality (Akdeniz et al. 2013). Therefore, consumers base their decisions on product-related extrinsic attributes (e.g., brand, packaging, price, labels, claims) due to missing sensory perception (Akdeniz et al. 2013). Intrinsic cues comprise physical characterization and nutritional composition of a product, which in turn affect appearance, smell, taste, sound, and texture/mouthfeel of the food (Enneking et al. 2007). Sensory perception, based on such intrinsic cues, influences consumers' perception of and experience with the food. Extrinsic and intrinsic product cues evoke different responses in consumers, which then jointly shape purchase decisions. For instance, recent studies have revealed that both the ingredients (intrinsic attributes, e.g., fat, sugar) and the labeling (extrinsic attribute) drive the choice of yoghurt (Johansen et al. 2010; Hoppert et al. 2012).

2.2 Consumer responses in food product evaluations

Numerous terms have been developed in the business and sensory literature to describe how consumers react to food (Mela 2001; Jaeger et al. 2011; Symmank et al. 2017). Although terms like food choice, food preference, food liking, or food wanting are often used interchangeably, it is useful to make a distinction.

Purchase intention is often used in marketing research to determine whether the consumer would really buy a product or not. It is assumed that the intention is directly influenced by the attitude towards the product and influences a subsequent behavior (Ajzen and Fishbein 2000). Even though consumers intend to purchase a food, they do not always translate this intention into behavior. A meta-analysis of Sheeran (2002) shows that intentions explain only 28% of the variance in behavior. Recent research in food decision making dealt with the intention-behavior discrepancies, for instance in the context of organic or ethical food consumption (Carrington et al. 2010; Aschemann-Witzel and Niebuhr Aagaard 2014).

Food liking or *food pleasantness* describe the immediate experience from the orosensory stimulation of eating resulting in a degree of pleasure or displeasure from a certain food (Mela 2001). It refers to a qualitative and hedonic evaluation of food which is judged against an internal reference. Hedonic evaluations are affective responses, whereby affective generally means an emotional reaction to a stimulus, and hedonic specifically refers to the emotion of pleasure/enjoyment or displeasure/aversion.

Food wanting is the intrinsic motivation of humans to engage in eating a food (Mela 2006). Consumers want to eat pleasurable food. Based on the assumption that consumers' food decisions in food-rich environments are increasingly driven by pleasure rather than the

physiological need to eat, food wanting reflects a motivational process that translates liking into action (Berridge 2009; Stroebe et al. 2008). While food liking remains relatively stable over time, food wanting can vary considerably over time and between situations (Mela 2001). Thus, food liking does not automatically cause food wanting. For instance, although an individual's general liking of fish is high and stable, the actual desire to eat fish is low at breakfast time. In recent food research, numerous attempts have been made to distinguish between liking and wanting (Finlayson et al. 2007, 2008). Even though liking and wanting can be manipulated and measured separately due to different neural substrates (Berridge 2009; Castro and Berridge 2014), they are not isolated systems, but rather interconnected (Havermans 2011).

Food preferences become useful in discussing decision making processes of consumers. Preference means a selection of a food among two or more alternatives available in a given time and context (Mela 2006). Again, the liking of a food does not necessarily cause food preference. Product A may be preferred over product B, even though neither is liked (e.g., in the case of a forced choice task in marketing research, Dhar and Simonson 2003). Contrarily, a food may actually not be liked, but nevertheless preferred because of a price reduction or health concerns. In sensory analysis, preference tests are used to measure the liking of sensory attributes. In marketing, preference often means choice. A third meaning refers to real sales data as an indicator for consumer preferences. However, in consumer and sensory research there is agreement that preference is more an outcome rather than an influencing factor (Peters et al. 2014; Chen and Lee 2015; Bianchi 2015; Byrnes and Hayes 2015). Contrarily, in nutritional science or medicine, food preference is seen as an influencing factor of dietary intake and eating behavior (e.g., Grimm and Steinle 2011; Takamura et al. 2014).

Keeping a wary eye on human behavior, food liking can be seen as an essential part of food wanting, and food wanting as a key contributor of food preference. However, liking of a food is only one of many factors in the formation of food preferences (Mela 2001). In the 1980s, a taxonomy of food acceptance and rejection was developed (Rozin and Fallon 1980; Rozin and Vollmecke 1986) which differentiates between three types of reasons for food preference or food aversion: First, *liking or disliking* of the intrinsic attributes (taste, smell, texture, or appearance); second, the *anticipated consequences* of food intake (e.g., health); and third, *food appropriateness*, i.e. the decision of whether food is deemed edible or not. In contrast to measuring food preference as an explicit decision in favor of a certain food (and implicit against a different food), there are several studies that explicitly measure *food rejection* (e.g., Giménez et al. 2015; Lima Filho et al. 2015). The rejection threshold method has been widely used to determine intensities of compounds or ingredients that become aversive

at high levels, for instance bitter compounds in chocolate, or off flavors in wine (Prescott et al. 2005; Harwood et al. 2013).

Previous researchers have criticized these distinctions by stating that liking, preference, or purchase intention measure hypothetical constructs as consumers evaluate products which do not exist on the market yet or which they probably would never choose in real market situations (Van Loo et al. 2011). Recently, the measurement of *willingness-to-pay* has been established as a better approximation of true preferences and a better prediction of field behavior (Lusk and Shogren 2007; Chang et al. 2009). For instance, in experimental auctions, consumers receive money and reveal the value of a real product. Even though auctions are mainly conducted as central location tests, they are considered a possibility to reduce excessive hypothetical bias.

2.3 Classification of research methods

2.3.1 Consumer research methods

In this article, the classification of consumer research methods follows the classification of Eid et al. (2015). According to them, consumer research methods can be roughly divided into self- and external assessment methods, on the one hand, and methods based on human behavior on the other (Table 1). Methods in commercial marketing and consumer research are commonly divided into qualitative and quantitative methods (Calder 1977). Self- and external assessment methods can be of qualitative and quantitative natures, whereas methods based on human behavior are mostly quantitatively driven. Qualitative research provides an in-depth but also subjective understanding of the consumer. Quantitative research often makes use of numerical measurement and statistical analyses that do not require further subjective interpretation of the researcher (van Kleef et al. 2005).

Tab. 1. Classification of consumer research methods based on the literature search of this article.

| Self- and external assessment methods | Methods based on human behavior |
|---|--|
| Observation | Computer-based techniques |
| Face-to-face interview | – Implicit associative test (IAT) |
| Focus group discussion | – Eye tracking |
| Word association / completion techniques | – Functional magnetic resonance imaging (fMRI) |
| Surveys and questionnaires | – Adaptive conjoint analysis (ACA) |
| | Computer-supported / non computer-based techniques |
| | – Choice task |
| | – Choice-based conjoint analysis (CBC) |
| | – Auction |
| → qualitative and quantitative techniques | → quantitative techniques |

Note. The categorization of methods is not completely free from overlaps, but provides a rough overview based on the present literature review.

In marketing research, direct *observation* either by the researcher or by videography and photography is used to record, for instance, the number of food items purchased or the path of consumers through the supermarket (Areni and Kim 1993; Basil 2011). *Face-to-face interviews* are based on personal interactions between researchers and participants. Depending on the research aim, the researcher uses structured (minimizing response options or preparing a question guide) or unstructured (next question depends on participant's answer) interview formats. In *focus group discussions*, a researcher provokes a discussion by forming a group of individuals to obtain insight into group interactions, individual motivations, and subliminal processes of human attitudes and beliefs (Threlfall 1999). Focus groups and interviews often serve as a preliminary stage of a research process, followed by further quantitative analyses. *Word associations* and *completion techniques* aim at identifying relevant determinants of consumers' decision making by asking them to freely think about a stimulus in order to extrapolate their behavior (Roininen et al. 2006). *Surveys or questionnaires* represent a way of gathering information about consumers' knowledge and awareness of products or brands, their attitudes and feelings towards them, and about demographics and lifestyles at a given point of time (Babin and Zikmund 2015).

Since product-induced inferences may be activated automatically and operate outside conscious awareness, the *implicit association test (IAT)*, a computer-based reaction-time measurement, is widely applied as a technique to measure underlying affects and attitudes (Greenwald et al. 1998). In food research, the IAT reveals, for instance, automatic linkages between light-colored food packages and healthiness (Mai et al. 2016). *Eye tracking* is an established method to allocate an individual's attention based on visual information (Velichkovsky et al. 1996). For instance, recent research explores how specific messages draw attention to visually suboptimal foods (Helmert et al. 2016). *Functional magnetic resonance imaging (fMRI)* provides a real-time analysis of brain activations and a detailed understanding of psychological processes underlying the evaluation and expectancy formation during food purchase decisions (Enax et al. 2015). In *choice tasks* participants have to choose one product from at least two alternatives (similar to preference tests in sensory research). Consumers tend to demand the "perfect product" (i.e., all preferred attributes at the lowest price level). To overcome this inflation of expectations, researchers use decomposition techniques (e.g., *choice-based conjoint analysis (CBC)*, *adaptive conjoint analysis (ACA)*) that shed light on how an individual's preference is constructed (Bettman et al. 1998). In many of the above mentioned research methods, participants are asked to make hypothetical choices or state hypothetical preferences instead of making real market choices. Participants believe their re-

sponses are inconsequential and they neither perceive gain nor loss from their decision (Lusk and Shogren 2007). In contrast, *experimental auctions* put participants in an active market environment including real economic consequences when stated preferences do not match their actual choice. Participants think about what they are actually willing to pay for a product.

2.3.2 Sensory research methods

The present article uses the classification of Lawless and Heymann (2010) to classify research methods in sensory research. Accordingly, the methods can be divided into three broad categories: difference testing, descriptive testing, and affective testing. Table 2 summarizes the sensory methods, their objectives, and their potential to be applied in marketing and business practice. For a comprehensive overview, see Lawless and Heymann (2010, p. 81).

Difference tests aim at determining whether there are detectable differences between products or product attributes (Næs et al. 2011). The results of difference tests do not indicate whether the difference is due to the taste, smell, or texture. If no difference was detected, this does not automatically allow the conclusion that the samples are completely similar, only that the participants were not able to detect a difference.

As it is not possible to deduce any qualitative assessments based on difference testing, *descriptive methods* are used to obtain detailed information concerning product appearance, taste, smell, or oral texture (Meilgaard et al. 2006). These methods allow for the description and quantification of inter-product sensory differences to provide relative sensory positioning of a set of products (Delarue and Sieffermann 2004; Varela and Ares 2014). Participants should be able to describe their perception by using sensory vocabulary without any hedonic evaluation.

Affective testing is the third broad category of sensory research methods. Unlike the first two categories, panels of untrained participants are required here. It is therefore one of the most important tools in determining food decisions of consumers. Affective tests either measure the order of liking for different products or a sensory attribute, or they measure the degree of liking using hedonic scales. Hedonic scales have emerged as an effective tool in market research to estimate product success or failure and, thus, have gained great attention in research (e.g., Hein et al. 2008; Jaeger and Cardello 2009; Lawless et al. 2010; Lim 2011). The most common scale is the nine-point hedonic scale (Peryam and Pilgrim 1957; Jones and Thurstone 1955). Just-about-right (JAR) scales combine hedonic evaluations with intensity ratings (Rothman and Parker 2009; Hoppert et al. 2013; Li et al. 2014a).

Tab. 2. Classification of sensory methods (based on Lawless and Heymann 2010) and possible applications in marketing and business practice (list is not exhaustive).

| Type of test | Category | Overarching question of interest | Participant characteristics | Field of application in marketing and business practice | Examples for tests | Objective and description |
|---|---------------------|--|----------------------------------|---|----------------------------------|---|
| Analytic | Difference testing | Are products perceptibly different in any way? | Semi-trained, trained | <ul style="list-style-type: none"> - Product development - Change of ingredients - Changes in manufacturing processes - Quality assurance - Observation of storage stability - Influence of packaging material - Developing me-too-products within a different company | Triangle test | Three samples are presented simultaneously to the participants and they either report which sample is the odd sample or which two samples are equal |
| | | | | | Duo-trio test | Participants receive a set of three samples simultaneously (whereby one sample is marked as reference) and they have to select this sample which they believe to be alike to the reference |
| | | | | | Paired comparison test | Participants have to determine which of two samples differs in a sensory attribute (one-tailed or two-tailed) |
| | | | | | Ranking | Participants receive samples with different intensities of a specific sensory attribute in random order and are asked to sort the samples based on this attribute either in ascending or descending order |
| Analytic | Descriptive testing | How do products differ in specific sensory attributes? | Untrained, semi-trained, trained | <ul style="list-style-type: none"> - Product development - Change of ingredients - Product comparison within or between companies - Attribute selection before consumer testing | Conventional profiling | A first phase reveals terms which describe the sensory profile of the sample (need for seeking a common language); within a second phase, the intensity of each attribute is evaluated on an intensity line scale |
| | | | | | Free-choice profiling | Participants use their own vocabulary to describe the product (no need for seeking a common language) and rate each product according to its attribute intensity; product samples are served in a monadic way, so that participants judge attribute by attribute of one sample before receiving the next sample |
| | | | | | Flash profiling | Combines individual panelist vocabulary development (as used in free choice profiling) with a simultaneous ranking of the whole product set |
| Hedonic | Affective testing | How well are products liked or which products are preferred? | Untrained | <ul style="list-style-type: none"> - Market research (product success or failure) - Product optimization | Preference test | Participants are asked which of two samples is liked best Participants are asked to rank several samples either in ascending or descending order based on their liking |
| | | | | | – Paired preference – Ranking | |
| | | | | | Acceptance test | Participants' acceptance can be displayed on a continuum from like to dislike (intervals between the nine categories are perceived as approximately equal) Measures participants' liking and reaction to a specific attribute using three- to seven-point scales with the end anchors "too much" and "too little", and the center point "just-about-right" |
| – Nine-point hedonic scale – JAR scale | | | | | | |

2.4 Conceptual framework of this review

Fig. 1 shows the conceptual framework of this review. The core of this figure shows that either intrinsic or extrinsic product attributes, or their interaction, have an impact on consumers' responses to available foods. The dependencies between intrinsic and/or extrinsic product attributes and various kinds of consumer responses are measured using consumer and sensory research methods.

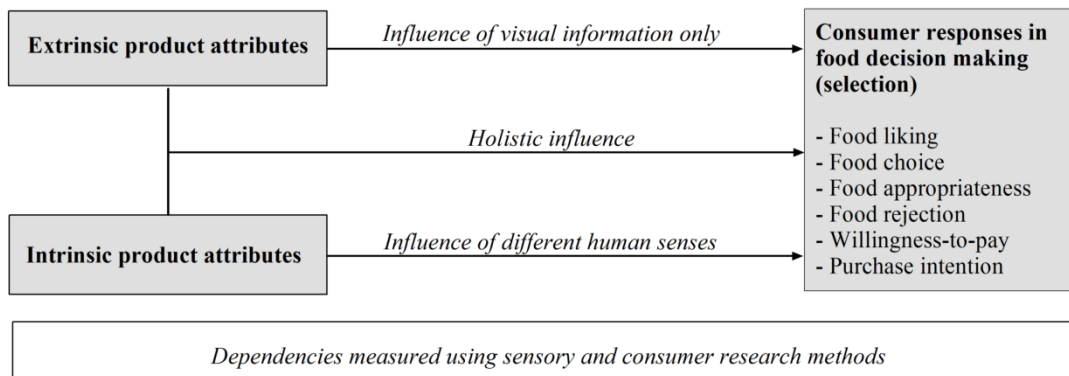


Fig. 1. Conceptual framework of the influence of extrinsic and intrinsic product attributes on product evaluation.

3 Identification and overview of relevant literature

3.1 Search process

Studies included in this review were initially obtained from the interdisciplinary electronic database *Web of Science*. The search was not limited to any publication date. The search string covered four main aspects: (1) dependent variables like *food choice*, *food preference*, *food acceptance*, *food liking*, or *food wanting* (or related terms that describe consumer responses to food); (2) influencing product attributes like *extrinsic*, *price*, *brand*, *packaging*, *label*, *information*, *intrinsic*, *sensory*, *taste*, *smell*, *flavor*, *sound*, *texture*, *appearance*, *fat*, *sugar*, *salt*, *fiber*, *protein*, *carbohydrates*; (3) content- and methodological-related exclusion criteria like *children*, *infants*, *animal*, *review*, or *overview*; and (4) the *consumer* as main actor. The search identified 331 articles. These articles were screened using a priori defined inclusion and exclusion criteria. Any study that empirically examines food decision making processes based on intrinsic and/or extrinsic product attributes fell within the scope of the inclusion criteria. In line with the research objective of this review to synthesize research methods and food product attributes examined in primary studies, overviews or reviews were excluded. All studies on animals, children, and infants were excluded (although the keyword combination contained these exclusion criteria, a number of corresponding hits had to be dropped), because this review focuses on the behavior of adult human consumers. Furthermore, exclud-

ed studies typically dealt with attention, perception, understanding, or awareness as dependent variables, examined sales or scanner data to measure consumer behavior, examined only isolated sensory attributes (e.g., freshness, sweetness), or examined attitudes towards a food type (e.g., organic or functional food) without manipulating intrinsic or extrinsic product attributes. The search was limited to journal articles that were published in English because all necessary information needs to be understood for content analysis. However, an article did not have to be published in peer-reviewed journals. After applying inclusion and exclusion criteria during title-, abstract-, and full-text assessment, 128 articles remained. Subsequently, an extensive forward and backward search within citations and references provided 1,143 matches. The retrieved articles underwent the same selection process as the initial studies. The final sample contained 602 articles⁶, published from 1964 to 2015 in academic journals. Fig. 2 displays the search process.

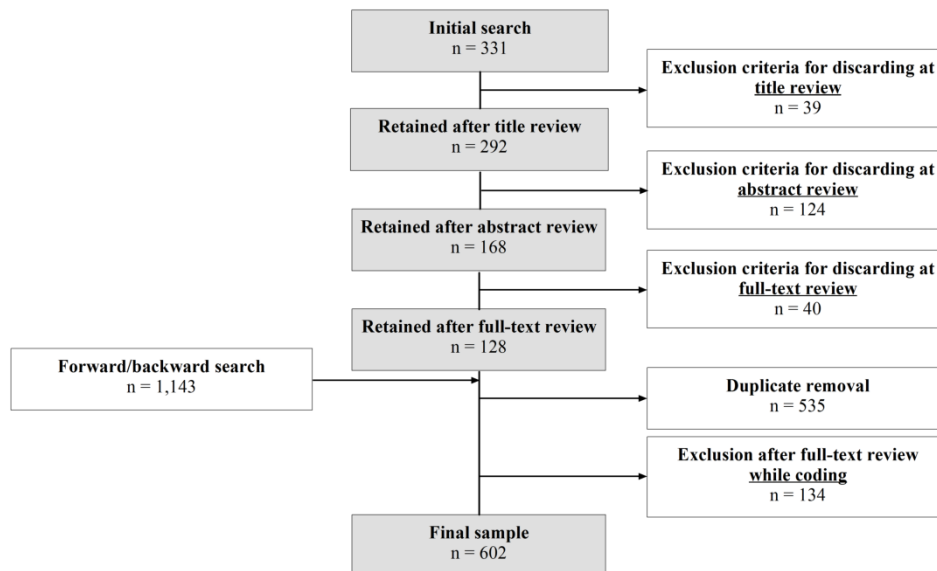


Fig. 2. Flowchart of the literature search.

3.2 Overview of included studies

Both consumer and sensory research are relatively young disciplines as originally there was little interest in consumer research in food (Grunert 2015). Recently, the research on extrinsic and intrinsic food product attributes has gained acceptance in consumer research, which is evidenced by a series of food-related studies in the top marketing journals (Chandon and Wansink 2007; Burton et al. 2009; Deng and Srinivasan 2013). Since the early 1990s, the number of published papers on extrinsic and intrinsic product cues has taken a great leap forward (Fig. 3), with 53 publications on average in the last five years. The 602 publications

⁶ The complete list of included articles is available on request.

were published in 138 different journals from marketing and consumer research (e.g., *Journal of Marketing Research*, Shah et al. 2014), nutritional science (e.g., *Journal of Nutrition Education and Behavior*, Vermeer et al. 2010), agribusiness (e.g., *Agribusiness*, Moro et al. 2015), business research (e.g., *Journal of Business Research*, Louviere and Islam 2008), sensory science (e.g., *Journal of Sensory Studies*, Kobayashi and Benassi 2015), and from various other fields related to consumer behavior, thereby underlining the interdisciplinary nature of food research.

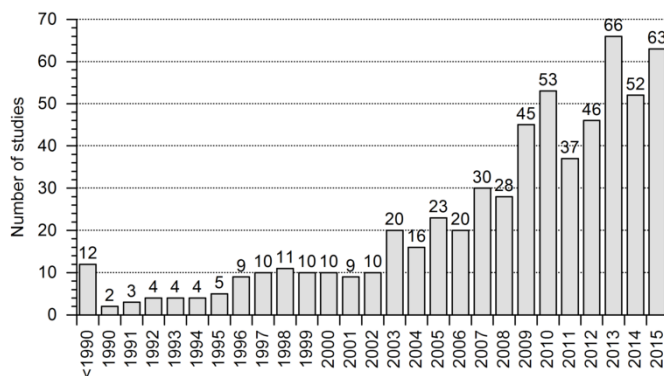


Fig. 3. Number of publications per year (n = 602).

Sample sizes in the present studies ranged from 10 to 11,322 participants per article with a median of 163 participants. In sensory research (e.g., profiling, triangle test) as well as in qualitative consumer research (e.g., face-to-face interview, focus group discussion), sample sizes are quite small as these methods often serve as pretests or to gain additional information about consumer attitudes and thoughts.

Considering the studies' geographic foci, research on food decision making is dominated by European- and North American-centric research. This might be due to the fact that compared to other countries, the United States and European countries hold a longer tradition in competitive marketplaces, and the progressively consumer-driven food sector fosters research in sensory and consumer food science (Linnemann et al. 2006). This disposition potentially explains the dominance of 311 studies with European samples and 166 studies in North America (151 in the USA). In Europe, most of the studies were conducted in Spain (43), the Netherlands (31), UK (31), Italy (29), Finland (26), and Germany (20). Contrastingly, Australia's agriculture and food industry has undergone a period of rapid change over the last few years (Delforce et al. 2005), and a total of 40 studies explicitly analyze Australian samples (e.g., Mueller et al. 2010; Morley et al. 2013; Van Doorn et al. 2015). Since 2004, scholars have been examining developing countries in Asia, such as China (e.g., De Steur et al. 2012), Thailand (e.g., Silayoi and Speece 2007), and Lebanon (Haddad et al. 2007). Research on

food decision making in South America started to appear in 2005. African countries are almost completely neglected in consumers' food decision making research so far, since other topics, such as unstable and unpredictable food prices, or affordability of staple foods, have been shown to be more relevant (Chapoto and Jayne 2009). From the 38 studies that adopt a cross-country perspective (i.e., the study was conducted with at least two samples from different countries), only 13 adopt a cross-continental perspective with at least two samples from countries of different continents (e.g., Asia and Europe: Tu et al. 2010; North America and Asia: Chung et al. 2012).

4 Discussion of the state-of-the-art

4.1 Content-based assessment

4.1.1 Extrinsic product attributes

The extrinsic product attributes were classified into brand, claims, product information, labels, packaging, and price (Fig. 7). *Labels* are studied the most often (353 studies), with the strongest increase among the extrinsic attributes since 2007. Different front-of-pack labeling systems have been developed by industry and organizations to promote health and dietary quality (Hodgkins et al. 2015). They aim at signaling key nutrients, for instance reduced fat (Norton et al. 2013), sugar (Miklavec et al. 2015), or salt content (Burton et al. 2009), reduced calories (Burton et al. 2009), or daily nutrient intake (guideline daily amounts: Hamlin et al. 2015; nutrition facts panel: Howlett et al. 2008). Research revealed that consumers struggle to use common labels and that these labels do not achieve government policy goals of facilitating healthy choices and lowering health risks (Maubach et al. 2014). Therefore, recent studies enhanced research on new types of labels and their influence on consumer choice behavior or product perception compared to common labels. For instance, the "multiple traffic light label" is designed in red (green) to signal unfavorable (favorable) nutrient levels with the aim of helping consumers to select more healthy food options (Koenigstorfer et al. 2014). Other labels provide a holistic rating for the entire product rather than for a single nutrient. In 2006, the "healthy choice logo" was launched in the Netherlands as a result of the effort of government and industry to guide consumers towards healthier food choices (Liem et al. 2012). The "Nordic Keyhole" is a label certified for healthy food alternatives (e.g., moderate amounts of sugar, salt, and fat, while being high in fiber) by the Swedish National Food Administration (Thunstrom and Nordstrom 2015). The development of the "Health Star Rating system" was funded by the Australian government in collaboration with industry, public health, and consumer organizations in 2014 (Maubach et al. 2014). It aims at providing an

easy way for consumers to choose foods that contain more positive nutrients and less risky nutrients. Other labels were designed to inform consumers that the company conforms to certain standards (e.g., organic label: van Doorn and Verhoef 2011; fair trade: Poelman et al. 2008; corporate social responsibility: De Magistris et al. 2015; animal welfare: de Jonge et al. 2015). Consumers also make inferences about the quality of a product, e.g., by using an origin label as a risk-reduction strategy (Chamorro et al. 2015).

183 studies of the dataset analyzed the influence of *price* on food decision making (Fig. 7; e.g., Grunert et al. 2009; Hellyer et al. 2012). Price appears as a relevant cue when consumers do not have adequate information about intrinsic quality cues (Acebrón and Dopico 2000).

183 studies paid attention to *product information* that is either provided verbally to consumers, or is part of the food packaging (but not necessarily included in a label) (Fig. 7). For instance, 82 studies examined how information about organic versus conventional production methods of food affect consumers' food acceptability (e.g., Laureati et al. 2013; Barbieri et al. 2015). Kaye-Blake et al. (2005), for instance, discussed consumers' reactions to information about genetically modified food. 77 studies delivered insights about how food evaluation or willingness-to-pay is affected by the knowledge of food ingredients, for instance fiber or antioxidants, that are often discussed as functional food ingredients (e.g., Ares et al. 2009; Ginon et al. 2009). Further studies examined which information on portion size is most promising in helping consumers to select appropriate food amounts (Vermeer et al. 2010; Just and Wansink 2014). Claret et al. (2012) investigated how information about storage conditions influences the decision making process around sea fish. Hersleth et al. (2011) evaluated effects of information about reduced salt content, prolonged aging time, and origin on the acceptance of dry-cured ham within a Norwegian consumer sample.

132 studies explored the impact of *claims* on consumer food choices (Fig. 7). Among these studies, common claims are health claims (e.g., Kozup et al. 2003; Wagner et al. 2015), nutrition claims (e.g., Gracia et al. 2009; Czarnacka-Szymani and Jezewska-Zychowicz 2015), and risk reduction claims (e.g., Hoefkens and Verbeke 2013; Coleman et al. 2014). The nutrition and health claims regulation was implemented to harmonize the rules of making nutrition and health claims across Europe (European Commission 2006; Gilsenan 2011). Nutrition claims highlight beneficial nutritional properties regarding energy or nutrients. Health claims are used for foods that improve the state of health and well-being. Risk reduction claims promise a significant reduction of a risk factor in the development of human diseases, provided that substantial scientific evidence is available (European Commission 2006).

The effect of *product brand* was analyzed in 68 studies (Fig. 7). Previous research has indicated that brand names guarantee homogeneity, identity, and quality in the decision making process (Acebrón and Dopico 2000). For instance, Di Monaco et al. (2004) evaluated consumer expectations and overall liking of pasta generated by the brand name. In an experiment of Mueller and Szolnoki (2010), participants rated hedonic liking and purchase intention of different brands of white wine.

54 studies focused on *packaging* attributes (shape, symbols, colors, messages), which have emerged as an important communication tool at the point of sale, similar to other marketing communication elements (Nancarrow et al. 1998; Rettie and Brewer 2000) (Fig. 7). Silayoi and Speece (2007), for instance, varied five attributes of the packaging of a convenience food. More recent research assessed consumer liking and purchase intention of olive oils based on bottle type, cap type, and notes on the label (Delgado et al. 2013). Kobayashi and Benassi (2015) analyzed the impact of packaging characteristics on purchase intention of instant coffee in refill packs and glass jars.

Concerning the joint analysis of extrinsic attributes, the findings show that price together with label was most often examined (Table 3, e.g., Costanigro et al. 2014), followed by product information and label (e.g., Ridley et al. 2015), and price and product information (e.g., Claret et al. 2012). Combinations of the other extrinsic attributes received comparatively less attention in food research (Table 3).

Tab. 3. Number of studies analyzing the combination of two extrinsic attributes.

| | Product | | | | | |
|----------------------------|----------------|---------------|--------------------|---------------|------------------|--------------|
| | Brand | Claims | information | Labels | Packaging | Price |
| Brand | - | 23 | 28 | 47 | 10 | 30 |
| Claims | | - | 43 | 59 | 8 | 53 |
| Product information | | | - | 105 | 12 | 98 |
| Labels | | | | - | 9 | 139 |
| Packaging | | | | | - | 15 |
| Price | | | | | | - |

Note. The sum exceeds the number of 602 studies due to multiple coding (one study may have analyzed more than one extrinsic attribute)

4.1.2 Intrinsic product attributes

The intrinsic product attributes were differentiated into appearance, smell, taste, and texture. As flavor can be regarded as a complex combination of olfactory and gustatory sensations perceived during tasting (ISO 2008), studies dealing with flavor were assigned to both smell and taste. 314 studies deal with *taste* and have received the greatest research interest among the intrinsic attributes. The proportion of studies dealing with food *appearance*, *texture*, and *smell* is relatively small (Fig. 7). No study was found that dealt with the *sound* of

food to influence food decisions. Table 4 shows how often the combination of two intrinsic attributes was analyzed. Most studies investigated *appearance and taste* (e.g., Di Monaco et al. 2003; Hobbs et al. 2014), followed by studies that measured consumer acceptance based on *taste and texture* of the food (e.g., Isleten and Karagul-Yuceer 2006; Bakke and Vickers 2011). *Taste and smell*, *smell and appearance*, and *smell and texture* have been neglected in research so far.

Tab. 4. Number of studies analyzing the combination of two intrinsic attributes.

| | Appearance | Smell | Taste | Texture |
|------------|------------|-------|-------|---------|
| Appearance | - | 6 | 42 | 18 |
| Smell | | - | 14 | 5 |
| Taste | | | - | 31 |
| Texture | | | | - |

4.1.3 Joint analysis of intrinsic and extrinsic product attributes

The analysis reveals that 192 studies investigated both intrinsic and extrinsic product attributes. The most frequently observed combination of intrinsic and extrinsic product attributes is *taste and label* (96 studies). As a typical example for this group of articles, Hoppert et al. (2012) integrated intrinsic and extrinsic attributes of vanilla yoghurt in an adaptive conjoint analysis by simultaneously varying fat content, sugar content, and flavor intensity. Tarancon et al. (2014) analyzed how facts about fat source and fat content on biscuit labels affect perceived healthiness and overall liking of the tasted product. *Taste* was also often analyzed *together with product information* (63 studies). For instance, in the study of Vazquez et al. (2009) participants were provided with information about salt and fiber content of biscuits and had to evaluate overall liking after tasting. A relatively large number of studies examined *taste and price* (49 studies), *taste and claims* (36 studies), *taste and brand* (34 studies), and *taste and packaging* (23 studies). Surprisingly, only a few studies were found that investigate product *appearance together with extrinsic attributes* (price: 20; product information: 15; label: 10; claims: 4; packaging: 4; brand: 3). Similarly, few studies combined *texture with extrinsic attributes* (3 - 8 studies). Finally, the number of studies that simultaneously analyzed the impact of *smell and extrinsic attributes* was very small (0 - 2 studies).

4.1.4 Measurement of consumer responses

The distribution of the dependent variables shows that consumer responses are most often conceptualized in terms of food liking (39%), followed by food choice (30%), purchase intention (17%), and willingness-to-pay (13%). Food appropriateness and food rejection are

rarely used for food product evaluations (each only 1%). 485 studies focused on a single dependent variable, and only 117 studies referred to several dependent variables.

4.1.5 Food categories

Regarding the type of food, the analysis reveals a wide range of foods that were grouped into nine food categories (Fig. 4). Furthermore, the categories “menu” and “different” were added in cases where a dish or different types of food were analyzed in one study. Bakery products were investigated in terms of bread (Rodbotten et al. 2015), biscuits (Tarancon et al. 2014), or cookies (Cavanagh et al. 2014). Almost one-fifth of the studies manipulated extrinsic or intrinsic attributes of alcoholic (e.g., Saenz-Navajas et al. 2013; Chaya et al. 2015) and non-alcoholic beverages (e.g., Li et al. 2014b; Kobayashi and Benassi 2015). A few other studies analyzed cereals/grain products (e.g., Khouryieh and Aramouni 2013), and dairy (e.g., Cliff et al. 2013; Chrysochou and Grunert 2014). Since 2000, a growing interest can be observed in the investigation of menus, like soups (e.g., Bolhuis et al. 2012) or fast food (e.g., Harnack et al. 2008). Aschemann-Witzel and Hamm (2010) investigated different products (yoghurt, breakfast cereals, and pasta) within one study and showed that products with a nutrition or health claim are preferred over products without claims. Only a few studies analyzed the choice of meat, fruits and vegetables, fish, oils and fats, and snacks and sweets.

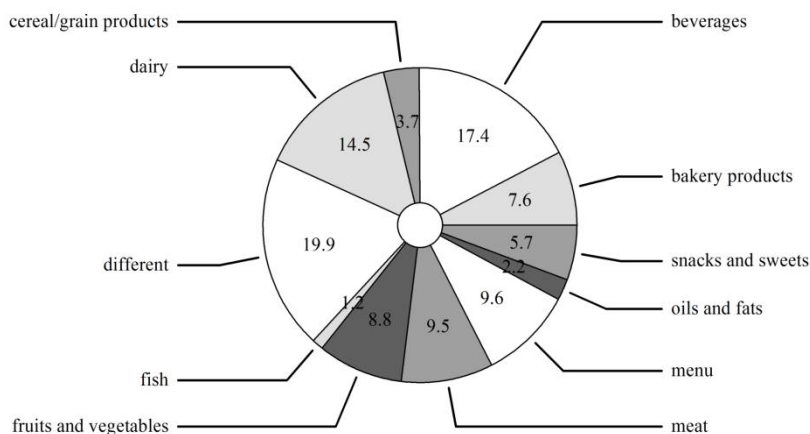


Fig. 4. Food categories analyzed in the present sample (n = 602).

4.2 Methodological assessment

4.2.1 Research methods and their interaction

The studies of the present dataset include all of the aforementioned research methods, except the IAT (Table 5). This might be explained by the fact that an IAT measures underlying affects and attitudes towards food, but not the final decision for or against a food

(which is the focus of the present article). 286 studies used only methods of consumer research and 166 studies used only sensory methods. 150 studies applied both consumer and sensory research methods. Most studies assessed consumers' food choice or liking using acceptance tests, followed by surveys and questionnaires (Table 5). About one quarter of the studies applied a choice task and 13% conducted conjoint analysis or profiling, respectively. All other methods seem to be underrepresented in consumer and sensory research, at least concerning the present sample.

Tab. 5. Methods of data collection used in studies of consumer food decision making (n = 602).

| Method of data collection | Frequency of use n | % of total studies |
|--|--------------------|--------------------|
| Sensory research methods | | |
| Triangle test / Duo-trio test | 5 | 1% |
| Paired comparison test | 6 | 1% |
| Ranking | 17 | 3% |
| Profiling | 81 | 13% |
| Acceptance test | 282 | 47% |
| Preference test | 15 | 2% |
| Self- and external assessment methods | | |
| Observation | 7 | 1% |
| Face-to-face interview | 26 | 4% |
| Focus group discussion | 41 | 7% |
| Word association / completion techniques | 13 | 2% |
| Surveys and questionnaires | 250 | 42% |
| Methods based on human behavior | | |
| Implicit associative test (IAT) | 0 | 0% |
| Eye tracking | 14 | 2% |
| Functional magnetic resonance imaging (fMRI) | 6 | 1% |
| Conjoint analysis | 79 | 13% |
| Choice task | 143 | 24% |
| Auction | 34 | 6% |

Note. The sum exceeds the number of 602 studies due to multiple coding (one study may apply more than one research method)

Multiple coding was possible when one study applied more than one research method. The most frequent combination *within the sensory research methods* is profiling and acceptance test (68 studies). For instance, Hernandez-Carrion et al. (2015) recently applied a flash profile first to generate a list of attributes that are appropriate for discriminating between milkshakes. Subsequently, consumers scored their degrees of overall liking and liking of sensory attributes. In all other cases, sensory methods were rarely (15 of 21 possible combinations with only 1 - 7 studies) or never (4 of the 21 possible combinations) applied within one study.

Within the consumer research methods, surveys/questionnaires were mostly combined with choice tasks (57 studies, e.g., Scott et al. 2008), followed by conjoint analyses (31 studies, e.g., Silayoi and Speece 2007) and auctions (12 studies, e.g., Thunstrom and

Nordstrom 2015). Focus group discussions as qualitative method were used in 18 studies before a survey was carried out (e.g., Coleman et al. 2014), and in 14 studies before a conjoint analysis was carried out (e.g., Chung et al. 2011). 11 studies combined eye tracking with choice tasks (e.g., Milosavljevic et al. 2012). 22 of the 45 possible combinations were only rarely combined (1 - 8 studies) and 17 of the 45 possible combinations have been neglected so far.

220 studies *jointly used consumer and sensory research methods* to examine consumers' food decision making. Fig. 5 illustrates that the most frequent combination of consumer and sensory research methods was acceptance test and surveys/questionnaire (93 studies). 18 studies jointly used profiling techniques and surveys/questionnaires. The dominance of the use of surveys/questionnaires in combination with other methods might be explained by the fact that surveys/questionnaires help to gather additional information about attitudes of the consumer and socio-demographic data (e.g., Lawless et al. 2013). Acceptance tests were jointly applied with conjoint analysis in 18 studies, and in 13 studies with choice tasks. Acceptance tests measure liking, but in marketing practice liking is not enough to determine whether the consumers translate their liking into real choice behavior. Therefore, choice tasks and conjoint analyses are used as additional tools to make empirical studies on food choice as realistic as possible (e.g., Roosen et al. 2007; Lusk and Parker 2009). In 17 studies, focus group discussions were used in preparation for a main study in which acceptance tests were finally conducted to measure food liking (e.g., Endrizzi et al. 2015).

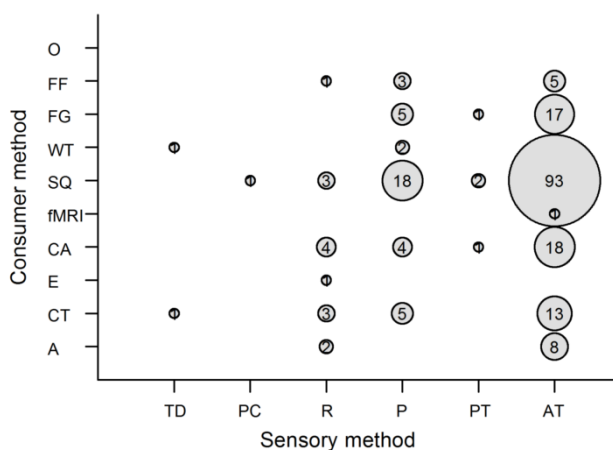


Fig. 5. Number of studies per sensory research method (x-axis) combined with consumer research methods (y-axis), $n = 220$; O... Observation; FF... Face-to-face interview; FG... Focus groups; WT... Word association, completion techniques; SQ... Surveys/questionnaire; CA... Conjoint analysis; E... Eye tracking, CT... Choice task; A... Auction; TD... Triangle test / Duo-trio test; PC... Paired comparison test; R... Ranking; P... Profiling; PT... Preference test; AT... Acceptance test.

4.2.2 Timeline of consumer and sensory research methods

Considering the development of research methods over time, Fig. 6 shows that the use of consumer methods and sensory methods, as well as their combination, was relatively low between the early 1990s and the turn of the millennium (which correlates with the findings of the development of studies in general, see section 3.2). A steady increase of general method use since 2002 is noticeable. Since 2004, the number of studies on food decision making research has been dominated by the use of consumer research methods, with currently more than 30 studies per year. Fig. 6 also demonstrates that research in food decision making still neglects to combine consumer and sensory methods, supporting the findings visualized in Fig. 5.

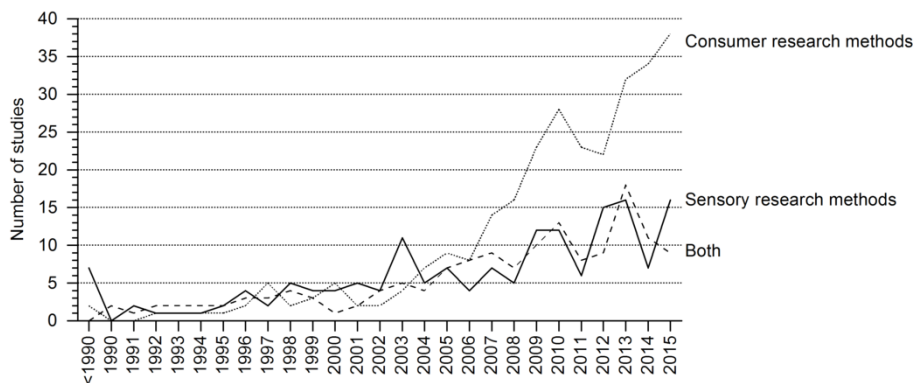


Fig. 6. Number of studies using methods of consumer research, sensory research, or both.

4.2.3 Study locations

The use of research methods is based on the assumption that the results have external validity and help in marketing. In contrast to this assumption, prior research showed that results of empirical studies are only valid for the investigated sample, for the particular product, and in a given context (Boutrolle et al. 2007). Thus, the results of food evaluation studies depend on the testing conditions. The most popular method to test food is the *central location test*. It usually takes place in a standardized laboratory under controlled conditions (e.g., sensory laboratory, university, market research institute). In contrast to the artificial conditions of central location tests, in *home-use tests* consumers take the product home for common daily use (Lawless and Heymann 2010). It is assumed that home-use tests yield more realistic data, but may cause the problem of uncontrolled conditions (i.e., researcher do not know who really rated the product and under what circumstances). *Field experiments*, conducted in supermarkets, cafeterias, or shopping centers, are explored in a real setting to collect data about which groups of consumers are most responsive to targeted products, or how a product performs

relative to competitive products (Lambrecht and Tucker 2015). With the increasing ubiquity of the internet, *web experiments* have emerged as a further approach to conduct behavioral experiments (Germine et al. 2012). In the present sample, 388 central location tests, 34 home-use tests, 141 field experiments, and 69 web experiments were identified. In 11 studies, both a central location test and a home-use test were conducted (e.g., van Doorn and Verhoef 2011); in 12 studies, a central location test and a field experiment (e.g., Shah et al. 2014); in 3 studies, a central location test and a web experiment (e.g., Coleman et al. 2014); in 3 studies, a home-use test and a field experiment (e.g., Kozup et al. 2003); and in 2 studies, a web experiment and a field experiment (e.g., Burton et al. 2009).

4.3 Integrative consideration of attributes and methods

Derived from a variety of intrinsic and extrinsic product attributes, the bubble charts in Fig. 7 disclose numerous combinations with research methods. In the following, some combinations are described for illustrative purposes.

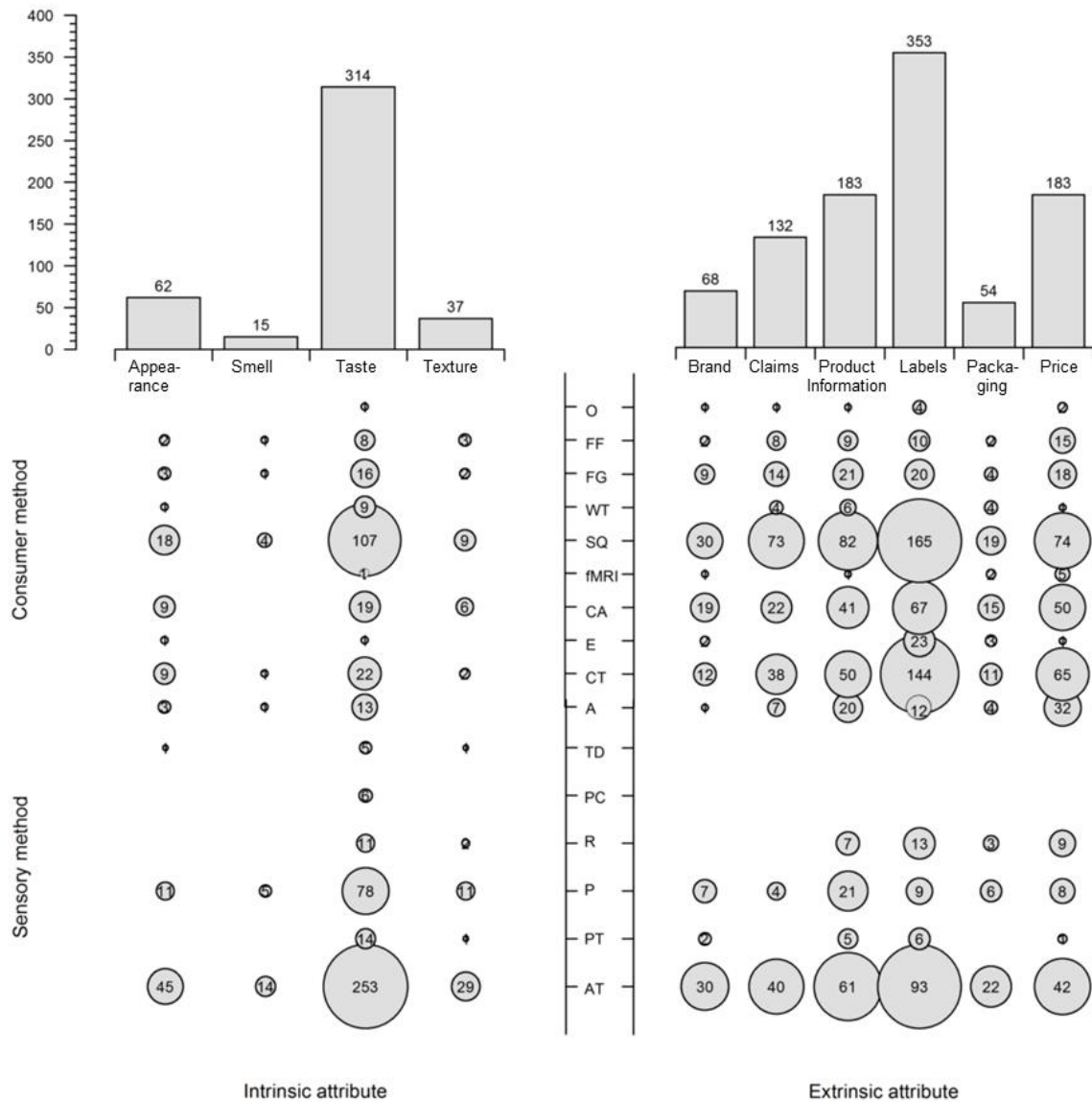


Fig. 7. Number of articles per intrinsic and extrinsic product attribute combined with research methods. The numbers in the bar charts and in the bubble charts may add up to more than $n = 602$ because one study may have analyzed more than one product attribute or applied more than one research method; O... Observation; FF... Face-to-face interview; FG... Focus groups; WT... Word association, completion techniques; SQ... Surveys/questionnaire; CA... Conjoint analysis; E... Eye tracking, CT... Choice task; A... Auction; TD... Triangle test / Duo-trio test; PC... Paired comparison test; R... Ranking; P... Profiling; PT... Preference test; AT... Acceptance test.

In the majority of studies dealing with food *appearance*, acceptance tests were conducted. For instance, in the study of Leksrisompong et al. (2012), consumers had to rate their overall liking of sweet potatoes with varying flesh color (orange, purple, yellow). Only one study investigated the effect of food appearance on food decision using eye tracking technology (Jantathai et al. 2014). *Smell* received far less attention in prior research with a maximum of 14 studies using acceptance tests (e.g., Koskinen et al. 2003; Bazala et al. 2015). *Taste* has been examined within a wide range of different consumer and sensory research methods with

a strong focus on acceptance tests (e.g., Kähkönen et al. 1999; Altisent et al. 2013) and surveys/questionnaires (e.g., Becker et al. 2011; Rossi et al. 2015). Recently, Biguzzi et al. (2015) explored the effect of fat- or sugar-reduced biscuits on food liking. In the study of Baixauli et al. (2008), consumers completed a questionnaire related to food, nutrition, and purchase intention of fiber-enriched muffins. Somewhat surprising is the combination of the fMRI technology and taste in the study of Enax et al. (2015). They investigated neural and behavioral processes underlying the influence of a fair trade label with a subsequent tasting of chocolates, presented either with or without a fair trade label. Even more common is taste evaluation using profiling techniques prior to a large consumer survey (e.g., Czarnacka-Szymani and Jezewska-Zychowicz 2015; Rodbotten et al. 2015). *Texture* was measured in terms of firmness as an indicator for the level of ripeness of fruits and vegetables using conjoint analysis (e.g., Gamble et al. 2010), thickness in dairy products and hardness in meat products using acceptance tests (e.g., Li et al. 2015; Cilla et al. 2005), or crunchiness in bakery products using free choice profiling (e.g., Tarancón et al. 2013). Notably, taste is the only intrinsic product attribute that was analyzed across all sensory methods.

The majority of studies dealing with product *brand* were either conducted using acceptance tests (e.g., Varela et al. 2010; Kim et al. 2013) or surveys/questionnaires (e.g., Pohjanheimo and Sandell 2009; Mueller and Szolnoki 2010). The same can be observed for *claims* with an additional focus on choice tasks. For instance, Naylor et al. (2009) demonstrated how conflicting (versus complementary) information about the validity of a health claim influences the likelihood of choosing a functional over a nonfunctional food. There are several studies that investigated *product information* using acceptance tests (e.g., Kihlberg et al. 2005), choice tasks (e.g., Brooks and Lusk 2010), and conjoint analyses (e.g., Morales et al. 2013). In contrast, only a few studies used ranking and fMRI technology. For instance, Lusk et al. (2015) measured brain activation while consumers made choices between two milk options varying in price and technology. Research on food *labeling* is clearly dominated by the use of surveys/questionnaires and choice tasks. Moreover, food labeling is the product attribute for which the most eye tracking studies have been conducted. In the study of Mawad et al. (2015), participants were asked to select their preferred yoghurt label while their eye movement was recorded. Few studies analyzed food *packaging* using sensory research methods. Instead, food packaging is dominated by consumer research methods, particularly surveys/questionnaires (e.g., Scott et al. 2008; Becker et al. 2011) and conjoint analyses (e.g., Quester and Smart 1998; Silayoi and Speece 2007). *Price* levels of food play a major role in consumers' food decisions, which is reflected by the inclusion of price as a crucial attribute in

many studies using different research methods. Prices were most frequently included in surveys/questionnaires, choice tasks, and conjoint analyses, in which consumers react to price levels that are preset by the researcher. In experimental auctions, participants disclose their willingness-to-pay according to the true value of their preferences (e.g., Thunstrom and Nordstrom 2015; Bruschi et al. 2015). Price and food labeling are the only two extrinsic product attributes that received attention across all consumer research methods. However, a few studies that focused on the sensory evaluation of a food also included the price into their research design.

5 Critical appraisal of the state-of-the-art and identification of research gaps

Knowledge about product characteristics which have the potential to influence consumer purchase behavior is important when developing food products and designing marketing strategies. Both sensory and non-sensory product attributes could have a major influence on consumers' choice or rejection. The next section highlights and discusses some research gaps and challenges of interdisciplinary research on food decision making.

Participants of the study

Consumer and sensory research traditionally employ different test panels, either (semi-)trained panels or untrained panels. The participants receive different tasks based on what is most efficient to solve a problem (Meiselman 2013). Previous research has already started to rethink this strict separation (Chollet et al. 2005; Worch et al. 2010), but clearly state that it always depends on the research aim. Future research should scrutinize their research aims and carefully select an appropriate test panel. Conducting research with a trained panel may be useful, for instance for the development of sensory attributes. However, using these attributes in consumer studies with untrained participants may cause confusion and uncertainty in food evaluation.

Product attributes

As can be seen in Fig. 7, the proportion of studies dealing with food appearance, texture, and smell as intrinsic product attributes is relatively small. No study was found that deals with the sound of a food and its effect on food choices. A recent review of Zampini and Spence (2010) showed that auditory stimuli (either food-related or nonrelated, such as background music) can have a dramatic effect on food perception. However, the important role of

auditory cues in food decision making is thus far underrepresented in food research. Concerning extrinsic attributes, research on packaging, including the full range of possible features, has been neglected so far. As a consequence, combinations like packaging and label, or packaging and claim received comparatively less attention in prior research. Almost one-third of the studies (192 of 602) comprise intrinsic *and* extrinsic attributes. This finding is consistent with previous studies (e.g., Hoppert et al. 2012; Akdeniz et al. 2013; Mai et al. 2016) which observed that a large share of the research focused on isolated effects, whereas only a small proportion of studies used a holistic approach to examine intrinsic and extrinsic product attributes simultaneously. In addition, some combinations of product attributes and research methods show a concentration of studies, whereas other combinations have been neglected so far (Fig. 7). On the one hand, more emphasis should be laid on research that focuses on more integrative approaches to describe real food choices. On the other hand, not every combination of attribute and method seems worth investigating. This needs to be checked against the demands of the practice.

Measurement of consumer responses

The findings of the present article show that 485 studies focused on a single dependent variable. 39% of the studies asked participants for their liking, and only 17% of the studies included purchase intention. As the liking or preference of a food is influenced by environmental factors (Scheibehenne et al. 2014; García-Segovia et al. 2015) and learning processes (Hermans et al. 2005; Morgan et al. 2014), one cannot conclude from food liking that consumers automatically translate their liking into purchase intention or behavior. With respect to this intention-behavior gap, future studies should be careful in drawing the right conclusions from research and transferring scientific results into practice. This could be achieved by measuring dependent variables at different stages of the decision making process (liking and purchase intention, preference and willingness-to-pay). In addition, it is largely difficult to harmonize dependent variables and their use across disciplines (same terms have different definitions, or different terms mean the same). For instance, various food liking and food wanting tests have been conducted, but it has proven to be very difficult to measure wanting separate from liking (Havermans 2011). Thus, the complexity of food research has led to isolated approaches in consumer and sensory science. This will require the development of common definitions across disciplines in future studies.

Food categories

The present article shows that only a few studies analyzed the choice of fish (1%), oils and fats (2%), or snacks and sweets (6%). Especially given the rising problems in public health, the analysis of specific food types (e.g., snacks and sweets), but also their correlation with physical activity (Lakerveld et al. 2014; Horodyska et al. 2015), should be intensified. 10% of the studies investigated menus. Testing a meal consisting of different ingredients is more complicated than testing consumer acceptance for single ingredients (Olsen et al. 2012). Because out-of-home and convenience-oriented food choices will continue to increase, more attention needs to be paid to these issues.

Consumer and sensory research methods

Findings of the present article show that there is an imbalance between well-represented and underrepresented methods in consumer and sensory research. While the application of acceptance tests and surveys/questionnaires are well documented, other methods as well as their combination were rarely or never applied. From Table 5 and Figure 5, one might conclude that not enough attention has been paid to auctions in food decision making research so far, although this approach has several advantages over standard approaches (e.g., surveys and focus groups; Jaeger et al. 2004). Auctions are currently being used mostly in experimental economics to measure the real monetary value of goods. As many studies focus on consumers' food liking and purchase intentions, their real willingness-to-pay is often disregarded. Auctions put great emphasis on realism by using real goods, real money, and market discipline of consumers.

The complex origins of food decision making processes in humans necessitate either new or combined research methods, or the simulation of situations (e.g., eye tracking studies) rather than merely on questionnaires and self-reports (Köster and Mojet 2006). Beneficial findings may result, for instance, from the combination of ranking tests with choice tasks or auctions. In hedonic ranking, participants rank several products based on their liking, but the researcher does not gain insights into whether the consumers would choose the product and what they are willing to pay for it. Moreover, the information obtained from preference tests does not say anything about the acceptance of the product because one product might be preferred over another even though both are disliked. For this reason, companies should not base their manufacturing and selling activities only on preference tests. Acceptance tests allow for the evaluation of only one product, whereas preference tests need at least one further product for comparison. However, preference tests could be combined, for instance, with conjoint

analyses in which consumers have to decide in favor of one product based on both sensory impression and extrinsic cues. For instance, Hoppert et al. (2012) integrated sensory assessment of yoghurt (varying in fat content, sugar content, and flavor intensity) and product evaluation based on packaging information into an adaptive conjoint analysis. Finally, observations of actual choices in real purchase situations could replace methods based on just asking for liking, wanting, or purchase intention (Köster 2009).

In the present sample, only 83 studies used qualitative methods (face-to-face interview, focus group discussions, and word association/completion techniques) and combined them with quantitative ones. However, the challenge for researchers will remain finding appropriate methods in the complexity of qualitative and quantitative tools to analyze consumer behavior (e.g., laboratory experiment vs. field experiment, with vs. without tasting). In sum, this article proposes the combination of several behavioral (e.g., choice experiment), sensory (e.g., ranking), neural (e.g., fMRI), and/or psychological (e.g., IAT) methods to enlighten the conceptualization of human food choice behavior. Especially in concrete industrial product development situations, it is crucial to have methods available that can be used to investigate both intrinsic and extrinsic attributes simultaneously.

Origin of the studies

The analysis reveals that 564 of 602 studies were conducted with samples of a single country. This finding is consistent with observations of previous researchers who criticize the limited geographical distribution of studies (Meiselman 2013). However, there are signs of a slow reorientation towards more multinational and cross-cultural food research, for instance in Europe, where a number of EU-funded projects have been performed (e.g., <https://www.dedipac.eu/>, <https://cosus.nmbu.no/>). This trend needs to be continued at least in the context of developing and testing global products.

Study locations

It is obvious from the present dataset that central location tests are most commonly used in consumer and sensory research, whereas the other approaches received less attention. To address real world issues, future studies need to find a better balance between laboratory research under artificial conditions and uncontrolled research (home-use tests, field experiments). Researchers will also need to understand how to conduct effective internet research using web experiments due to an increased online shopping behavior. Moreover, different

approaches should not be applied comparatively to answer a research question, but instead to collect data at different stages of the study (e.g., pretest vs. main study).

6 Conclusions and limitations

The present article provides an overview of the extrinsic and intrinsic food product attributes in consumer and sensory research. 602 studies, published from 1964 to 2015 in 138 academic journals, were analyzed. Over the last two decades, an increase in the number of publications can be observed, with the majority of studies being conducted as central location tests in Europe and North America. The analysis revealed a wide range of tested foods that were grouped into nine food categories, of which beverages, dairy, and menus were investigated most often. Responses of consumers were usually conceptualized in terms of food liking, food choice, purchase intention, and willingness-to-pay. Most studies assessed consumers' food evaluation using acceptance tests and surveys/questionnaires. The most frequent combination within the sensory research methods was profiling and acceptance test. Within the consumer research methods, surveys/questionnaires were most often combined with choice tasks. Consequently, the most frequently used combination of consumer and sensory research methods was acceptance test and surveys/questionnaires.

Concerning the intrinsic product attributes, taste has received the greatest research interest so far and is often analyzed in combination with appearance. Taste has been examined with a strong focus on acceptance tests and surveys/questionnaires. Taste was the intrinsic product attribute that was analyzed using all sensory methods. Food labeling was the most often studied extrinsic product attribute, followed by price, with both being considered in combination with many other extrinsic attributes. Research on food labeling was clearly dominated by the use of surveys/questionnaires and choice tasks. Price and food labeling were the only two extrinsic product attributes that received attention across all consumer research methods. The most frequently observed combination of intrinsic and extrinsic product attributes was taste and label.

In sum, this review has presented detailed evidence of which product attributes influence consumers' food decision making and which methods have widely been used for analyzing human behavior in consumer and sensory research. In consumer research, researchers aim particularly at obtaining knowledge on which and how individuals use informational stimuli that are provided by packaging or advertising without physically modifying the product. In contrast to complex purchase decisions (e.g., buying a smart phone), food decision making is conducted repeatedly so that, once a particular food has been selected, sensory properties are

usually borne in mind and remembered in subsequent purchases. Sensory scientists mainly focus on analyzing the impact of food ingredients or processing parameters on intrinsic sensory attributes which determine perceived quality (e.g., appearance, taste, smell, sound, texture). Although many studies have been found in both consumer and sensory literature, it was shown that many attributes, particularly the combination of extrinsic and intrinsic attributes, have not been researched sufficiently so far. With regard to *Research Question 1*, future studies are well advised to expand research on product attributes to derive further useful practical implications.

The findings of this review pose further dilemmas for researchers because of the variety of methods that can be used to explain consumers' food decision making. With regard to *Research Question 2*, the research still suffers from a lack of interdisciplinarity and more attention needs to be paid to using methods from both disciplines in future studies. Sensory scientists, with their expertise in testing intrinsic attributes of food, are able to predict consumer preference and choice. However, to ensure the required external validity to achieve marketing objectives, sensory researchers will need to incorporate elements of the marketing context into their study designs. Thus, marketing and sensory approaches have to be linked to realize not only one-time, but repeated food purchases.

The pooling of scientists' knowledge about consumer attitudes towards both intrinsic and extrinsic product attributes and competencies on how to measure consumer behavior remains an obstacle for further research that has to be overcome. Neither consumer nor sensory science needs to be changed, since they are well established disciplines and have developed an important pool of methods. Instead, with regard to *Research Question 3*, this review calls for ways to timely strengthen the link between consumer and sensory science. From a purely scientific perspective, researchers have to consider both marketing and sensory aspects when studying consumers' food decision making. From the perspective of a practitioner, it is highly relevant that new product development be based on the cooperation between consumer and sensory science as products are potentially more likely to meet consumers' needs and lead to improved satisfaction. This allows the food industry to avoid many unnecessary product failures.

While the present article has provided useful insights into the state of the art of the research in consumers' food decision making, there are *limitations* that have to be mentioned. The selection process of the studies caused the exclusion of certain publication types. As stated in section 3.1, this review aims to analyze research activities based on primary experimental studies. Therefore, literature was included selectively by focusing on journal articles.

It is conceivable that research is also published in working papers or conference proceedings that were excluded. Considering the need to understand study content correctly for the coding procedure of this review, only studies that were published in English were included. However, studies did not have to be published in peer-reviewed journals, as it would narrow the scope of studies. An extensive forward-backward search was conducted and studies were screened using a priori defined inclusion and exclusion criteria. Therefore, it is assumed that the study sample is representative with respect to the research efforts in consumer and sensory science. This article does not claim completeness, but intends to provide an overview of existing knowledge and to deduce implications for further research in food decision making. However, since the article does not provide any information about the explanatory power of the results of the primary studies, it remains unclear whether the limited attention given some attributes, methods, or their combination is due to the fact that they are simply not as interesting. Research and corporate practice are invited to propose new methods of investigating consumer food choices, assuming it is practically relevant.

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E.1 – Light and pale colors in food packaging: When does this package cue signal superior healthiness or inferior tastiness?

Abstract

In food packaging, light and pale colors are often used to highlight product healthiness. What has been largely overlooked is that this seemingly positive health cue may also convey another crucial piece of information. It is this paper's premise that light-colored packages evoke two opposing effects: they stimulate favorable health impressions (health effect) and they activate detrimental taste inferences (taste effect) which jointly guide the purchase decision. To contribute to a better understanding of when this package cue is an asset or a liability, this research elucidates the boundary conditions under which the opposing effects operate. The unfavorable color-induced taste effect should be particularly dominant when (i) consumers have a strong need to make heuristic taste inferences (i.e., when tasting is not possible) and (ii) when health is not the overarching goal (e.g., for less health-conscious consumers). A series of experiments manipulating actual food packages confirms that the package health cue can indeed trigger negative taste associations in the consumer's mind that backfire. Marketers therefore are advised to consider the identified contingencies carefully.

Keywords

Packaging, Color, Experiment, Food Decision Making, Health Consciousness, Unhealthy = Tasty Intuition

1 Introduction

With the steady rise of diet-related diseases (Ng et al. 2014) and the growing emphasis on healthy nutrition, health-concerned consumers have become a sought-after market segment (Prasad, Strijnev, and Zhang 2008; Trivedi, Sridhar, and Kumar 2016). To highlight the healthiness of their products, marketers can use a variety of package elements (e.g., labeling, brand names), but also more subtle cues, such as package shape (Folkes and Matta 2004; Wansink and Van Ittersum 2003), size (Argo and White 2012; Scott et al. 2008), or images placed on the package (Deng and Kahn 2009; Madzharov and Block 2010). Particularly visual design elements seem to be effective tools to convey symbolic meaning in a subtle manner. One such trend that has emerged is to use package color strategically. As colors differ in their associated weight (Karnal et al. 2016; Pinkerton and Humphrey 1974), lighter tones may signal that a product is less heavy (less fatty or sugar-laden) and, thus, healthier. Possibly with such associations in mind, some companies use pale packages to promote healthier options (e.g., diet products). Intuitively, this seems a reasonable strategy because color is known to shape consumer judgment (Labrecque, Patrick, and Milne 2013). This research posits that light-colored packaging is not always an asset because, ironically, this supposedly positive health cue may spark doubts about other valued product characteristics.

This paradoxical package color effect builds on recent research showing that humans hold diverse (and sometimes opposing) lay theories about certain market phenomena (Deval et al. 2013). It is for this reason that consumers may draw different and even contradicting conclusions about the very same visual package cue. While aiming for healthiness perceptions, companies may unwillingly transport a different crucial piece of information. Food shoppers might link colors to sensory characteristics, so that pale packages trigger less favorable taste associations (less intense taste or flavor). In consideration of the dominant role of tastiness in food decision making (Raghunathan, Naylor, and Hoyer 2006), such intuitive taste impressions potentially undermine the effectiveness of the package health cue (and thus sales). This challenges conventional wisdom and raises the seemingly simple question of whether light-colored packaging helps or hurts.

The paper's framework outlined in Figure 1 suggests that the color intensity effects are not unidirectional. The package cue is expected to generate both positive health impressions and negative taste impressions. From a retailing perspective, it is particularly important to understand when the taste inferences counteract superior health expectations. We expect that circumstances exist in which light tones indicate health ("health effect"), but signal a loss in taste ("taste effect") under other conditions. From a theoretical perspective, this research

provides new insights into the moderating mechanisms that strengthen (and weaken) the two opposing color effects. The paper suggests that consumers differentially rely on color intensity of food packages, depending on (i) the need to make heuristic inferences about taste (i.e., accessibility of sensory properties) and (ii) the pursuit of a health goal at the time of judgment (i.e., health consciousness). First, light-colored packages should be particularly likely to evoke the detrimental taste effect when consumers are unable to assess (“taste”) the food’s sensory properties directly, such as in typical in-store purchase decisions. To fill in this gap in their knowledge, food shoppers have to refer to package color as a visual taste cue. By contrast, when having already tasted the actual product, consumers have a much weaker need to rely on (over-)simplifying heuristics about inferior tastiness. Secondly, the shopper’s goal may further moderate the color effects. As consumers pursue different goals when shopping for food (indulgence vs. health goals), health-conscious consumers are expected to rely on the package health cue differently than their less health-conscious counterparts.

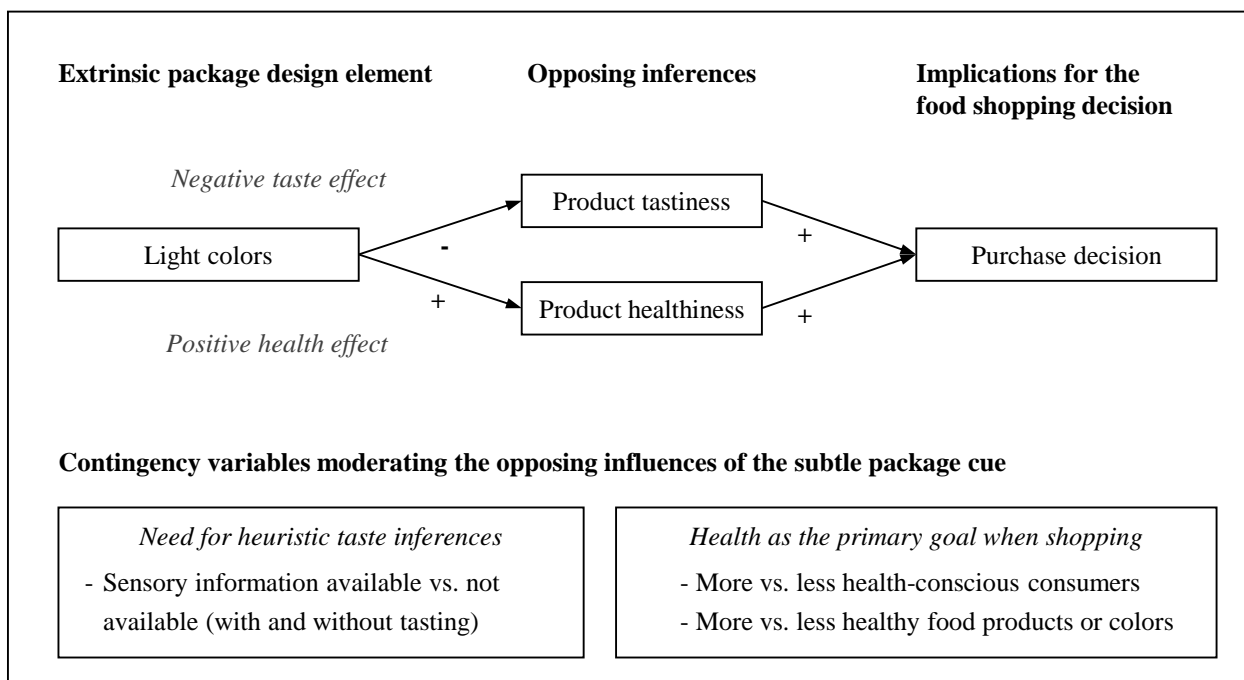


Fig. 1. Conceptual framework.

In the following sections, we present our theory and conceptual framework. A series of six studies employing diverse methods (e.g., reaction time measurement, choice experiments) systematically examines the boundary conditions under which the package cue’s health and taste effects are likely to occur. The paper concludes with a discussion of the findings and directives for marketing managers. As this research will show, pale packaging is a double-edged sword for retailers and food providers because this pervasive package cue has different meanings to different shoppers in different food retail environments. Depending on

the suggested contingencies, light colors can be an asset or a liability. Such knowledge is essential to develop successful packaging strategies and to promote (healthier) food products more effectively.

2 Theoretical background

2.1 Role of product packaging

Product packaging fulfills vital logistic purposes (e.g., protection, transportation, storage of the product), but it also has two important functions in the decision making of consumers (Sara 1993). First, the packaging is a lever to attract attention and to differentiate products visually (Ampuero and Vila 2006). Secondly, packaging conveys information, abstract images, and symbolic meaning (metaphors, associations, aesthetics, etc.) (Silayoi and Speece 2004; Sundar and Noseworthy 2014). Shoppers apply such mental shortcuts to draw conclusions about products or brands, especially when they have to bypass gaps in their knowledge as information is often incomplete (Deval et al. 2013). Several package elements (e.g., shape, labeling, brand names or product images) serve as symbolic cues that affect in-store purchase decisions, post-purchase evaluations, and even the consumed quantity (Argo and White 2012; Deng and Kahn 2009; Deng and Srinivasan 2013; Krishna 2006; Madzharov and Block 2010; Scott et al. 2008; Wansink and Van Ittersum 2003; White et al. 2016; Yang and Raghuram 2005). With color intensity, this research focuses on a crucial visual design element. As it is perceptually salient, package color primes perceptions even from a distance (e.g., when approaching a shelf in a store) and color is often noted before shoppers are able to perceive other verbal or graphic package cues.

2.2 Color and color intensity

Research on the perception of color has emerged in various disciplines (psychology, physics, art, marketing, etc.). We acknowledge this extensive background and approach the issue from a consumer behavior perspective (Labrecque, Patrick, and Milne 2013 for a review). Color is a visual perceptual property that is derived from the reflection of light. Colors are characterized by the light's wavelengths that are perceived by the human eye (the visible light ranges from 400 to 700 nm). In colloquial speech, a color is associated with a certain spectrum of light (e.g., yellow: 560-590 nm). There are several multidimensional typologies that distinguish between different appearance parameters (Gorn et al. 1997), such as hue, lightness, chroma, or saturation.

As a result of associative learning (Balsam and Gallistel 2007; Labrecque, Patrick,

and Milne 2013), consumers have established close associations with specific colors because they occur in their (shopping) environment. For example, individuals have learned that red objects require attention (red light, stop signs, discount labels, etc.) (Ogden et al. 2010; Puccinelli et al. 2013). By referring to such associations, consumers tend to infer meaning from a product's color (Garber, Hyatt, and Starr 2000; Herbig and Milewicz 1996). Likewise, consumers differ in their perception of different package colors (e.g., Delaby, Balikdjian, and Pohl 2011; Garber, Burke, and Jones 2000; Karnal et al. 2016). Ares and Deliza (2010), for example, demonstrate that milk desserts with black (vs. white or yellow) packages are expected to contain more chocolate.

While there is ample evidence documenting color's impact on product judgments, few studies considered that the human eye further distinguishes color with respect to the aforementioned appearance properties (Labrecque, Patrick, and Milne 2013) and, most importantly, color lightness, which is within the scope of this research. Color lightness refers to differences in the degree of a color's intensity that is caused by distinct wavelengths within a commonly accepted main band of light (e.g., dark and light-green). There are indications that the color lightness of a product itself shapes consumer perceptions (Hoegg and Alba 2007; Lavin and Lawless 1998; Tom et al. 1987). It is plausible that similar inferential beliefs dominate the perception of the packaging. This research focuses on two different meanings that consumers infer from light tones, but which have opposing consequences, namely, positive health inferences and negative taste inferences.

2.3 Positive package color effect: light colors as a health cue

Pale packaging may be used under the assumption that consumers rely on light colors as a source of symbolic meaning regarding product healthiness. Product healthiness refers to expectations about a product's health benefits and the influence of the product on one's state of health. Color lightness effects on health judgments can be explained with associations of heaviness as colors were shown to differ in their perceived weight (Pinkerton and Humphrey 1974). That is, some colors are perceived heavier (e.g., red) than others (e.g., yellow) (Karnal et al. 2016). Due to a halo effect, consumers may establish an associative linkage between the perceived weight of light colors and healthiness in their mind (i.e., the product is less heavy on the stomach). Hence, food shoppers might be prone to infer that products with pale packages are healthier. Perceived validity of this assumption may be strengthened by the fact that in many industrialized countries pale and less intense colors are used for diet options or healthier products, whereas conventional variants often employ more intense colors (Croll,

Neumark-Sztainer, and Story 2001).

Despite its role as a health cue in marketing practice, research on the interplay with other valued attributes is sparse. Color-related research in neighboring disciplines has focused on taste perceptions (e.g., Becker et al. 2011; DuBose, Cardello, and Maller 1980; Harrar, Piqueras-Fiszman, and Spence 2011; Lavin and Lawless 1998). Yet, isolated approaches bear the risk of misleading conclusions, and the need of jointly examining the taste dimension and the healthiness dimension was recognized in several contexts (product names: Irmak, Vallen, and Robinson 2011; health claims: Naylor, Droms, and Haws 2009; reduced-fat/sugar: Mai and Hoffmann 2015; flavor intensity: Mai et al. 2014; vice-virtue bundles: Liu et al. 2015).

2.4 Negative package color effect: light colors as a signal to a taste decrease

Individuals are known to draw opposing inferences from the very same cue (Deng and Srinivasan 2013; Deval et al. 2013). This research extends the current discussion about contradictory naïve inferences to package cues. In this context, a positively valenced package health cue might be negatively associated with further product benefits, and more precisely, taste evaluations. Accordingly, recent research shows that consumers are confronted with competing goals when balancing their long-term health considerations with the short-term goal of indulgence (Finkelstein and Fishbach 2010; Laran and Janiszewski 2009; Wilcox et al. 2009). According to Raghunathan, Naylor, and Hoyer (2006), people intuitively believe that a food's taste and healthiness are inversely related. As a consequence of such deep-seated intuitions, consumers tend to judge unhealthy products inherently tastier than more healthy options (albeit this may be objectively inaccurate). This taste stigma of healthy food was shown to guide food choices or enjoyment (Laran 2010; Laran and Janiszewski 2009; Raghunathan, Naylor, and Hoyer 2006; Wilcox et al. 2009) and it is even reflected in consumer body fatness (Mai and Hoffmann 2015).

In consideration of the competing decision-making goals, light-colored packages should exert two effects that work in opposite directions. On the one hand, light tones trigger a positive health effect because they are associated with a reduction of some food constituents (e.g., low fat or sugar). On the other hand, there is reason to believe that the cue generates a negative taste effect because light tones are also associated with sensory properties (less intense color↔less intense taste, flavorless, bland, etc.). For certain foods (esp. fruits and vegetables), richer colors signal optimal development, ripeness, and quality. In focus group interviews, consumers characterize the pale packaging of healthier options as “boring and dull”,

while the conventional variant “catches your eye because of the bright colors” (Hamilton et al. 2000, p. 501). Likewise, “if the pack is dull, the food taste could be guessed as boring” (Silayoi and Speece 2004, p. 617). We observed similar taste inferences in exploratory interviews that were conducted in the preliminary stage of this research. For these reasons, we expect light-colored packages to evoke unfavorable taste associations that can even offset the positive implications of favorable health impressions.

H₁ The intensity of the packaging color evokes opposite effects on food evaluation: Products with light colors are perceived healthier than products with regular colors, whereas products with light colors are perceived as less tasty than products with regular colors.

The color-induced judgments of taste and health will jointly guide the purchase decision. Marketers are keen to learn when light tones are an asset (positive health effect) or a liability (negative taste effect). Yet, prior research has not examined the factors that moderate the opposing effects. Our framework (Figure 1) posits that the effects suggested with H₁ are more or less influential depending on boundary conditions. Whether shoppers perceive color intensity as diagnostic (relevant) for judgment formation is expected to critically depend on (i) the need for heuristic taste inferences (i.e., the accessibility of sensory information) and (ii) the extent to which the package is judged under a health goal (i.e., the consumer’s level of health consciousness).

2.5 The need for taste inferences: moderating effect of the availability of oral sensory information

As the first boundary condition, reliance on light-colored packaging may depend on the shopper’s need to make inferential judgments. People are particularly likely to use a certain cue as an input for decision making if this information is perceived as useful for achieving the desired goal (Alavi, Bornemann, and Wieseke 2015; Lynch, Marmorstein, and Weigold 1988). Our framework posits that package color’s negative taste effect is more powerful when a food product’s sensory properties cannot be assessed directly through tasting and the judgments are solely based on visual perception. By contrast, the health effect should occur even when oral sensory information is available. This assumption builds on the distinct qualities of taste and health evaluations. Tastiness is an experience quality that can be assessed upon consumption, whereas product healthiness is a credence quality which is difficult to ascertain even after consumption.

When tastiness is a hidden attribute (e.g., before the purchase), food shoppers may be compelled to rely on extrinsic package cues. As they are unable to assess intrinsic sensory properties by tasting, consumers should be prone to form tastiness evaluations on the basis of heuristic conclusions about the packaging. By contrast, when oral sensory information is available as an input for judgment formation (e.g., after consumption), food shoppers should have much weaker need to deduce this experience quality from a visual cue. Consistent with this logic, research (Grunert 2005; Hoppert et al. 2012a; Mai and Hoffmann 2015) shows that taste evaluations mainly build on actual sensory experiences of intrinsic properties, rather than on expectations based on extrinsic cues. Likewise, Luchs et al. (2010) show that lay theories guide evaluations of attributes less strongly once these properties are no longer missing. Note that it is still possible that color intensity affects taste evaluations after a food product has been tried. Several extrinsic cues (e.g., labeling, health claims, product names) were shown to bias taste experiences (e.g., Irmak, Vallen, and Robinson 2011; Litt and Shiv 2012; Naylor, Droms, and Haws 2009; Wansink and Park 2002; for a review see Piqueras-Fiszman and Spence 2015). In other words, we suggest that reliance on light colors as a negative taste cue is stronger when food shoppers base their judgments only on visual perception than when they are able to take into account sensory perception as well.

In contrast to taste, healthiness is a credence quality as this attribute can hardly be detected by human senses. Accordingly, individuals have difficulties to taste differences in sugar or fat (Hoppert et al. 2012b) and they have to refer to a product's labeling to form health judgments (Mai and Hoffmann 2015). Owing to the fact that product healthiness is still a hidden (credence) quality after tasting, consumers are expected to rely on package color lay theories, even in the post-consumption phase when sensory information is no longer missing. We therefore postulate:

H_{2a} The availability of sensory information moderates the opposing effects of light-colored packages. The negative color-induced taste effect is stronger when oral sensory information is not available than when taste evaluations can be based on actual sensory experiences.

H_{2b} The pattern suggested with H_{2a} differs between taste and health evaluations. The color-induced health effect is also likely when judgments are based on oral sensory experiences.

The differential effects suggested with H_{2a/b} should drive the final intent to purchase. Thus, the negative taste effect on the purchase decision is more likely to counter the positive

health effect when oral sensory information is missing and the need for heuristic taste inferences is strong. Our framework proposes a second important boundary condition according to which package color effects are expected to vary with the goal that is activated at the time of judgment.

2.6 Pursuit of a health goal at the time of judgment: moderating effect of health consciousness

Consumers differ in the extent to which their decisions are based on cues indicating health benefits (Jayanti and Burns 1998; Moorman and Matulich 1993; Naylor, Droms, and Haws 2009). We expect that consumers seek and interpret a package cue from the perspective of their consumption goals. If shoppers are pursuing a health goal, they should be more likely to interpret pale packages as a health cue, rather than a signal for a taste decrease. Health consciousness is therefore deemed a relevant consumer characteristic to moderate the opposing effects of this cue.

Health consciousness captures the degree to which an individual is actively engaged in behaviors to improve or maintain their state of health (Gould 1988). Health-conscious consumers monitor their health and are ready to take the necessary actions (Michaelidou and Hassan 2008). They are more adept and more willing than less health-conscious consumers to pursue an overarching health goal. To achieve this goal, health-conscious consumers place greater emphasis on health-related attributes and they are more sensitive to extrinsic cues indicating health benefits (Mai and Hoffmann 2012, 2015; Naylor, Droms, and Haws 2009) than less concerned individuals. Consequently, the positive effect of color-induced health impressions should be strengthened with elevating levels of health consciousness. By contrast, the detrimental taste effect should be attenuated because consumers with a strong health orientation are more ready to accept deficits in taste for products with health benefits (Verbeke 2006). For less health-concerned individuals, we expect the opposite pattern because health aspects are less relevant for these consumers (Naylor, Droms, and Haws 2009). In other words, light colors might signal healthiness when a health goal is active (or salient) during the judgment, but signals a loss in taste when this goal is less relevant.

H_{3a, b} Health consciousness moderates the effects of light-colored packages on the purchase decision, such that (a) the color-induced health effect plays a stronger role in decision making and (b) the taste effects plays a weaker role with elevating levels of health consciousness.












It is plausible that not only consumer characteristics shape the central consumption goal. Likewise, aspects of the retail environment and the product may determine which inference rule is activated and how a cue is interpreted. For example, healthier variants should be likely to make a health goal salient (Deng and Srinivasan 2013) and thus the product is judged in this context. Hence, the implications of H₃ should extend to healthy (vs. unhealthy) products or attributes.

2.7 Flow of studies

A series of experiments tests our theoretical framework using a wide range of methods. Table 1 presents an overview of the objectives and stimulus materials of these studies. In a preliminary step 1, reaction-time tests and a choice experiment explore the role of light-colored packaging as a subtle health cue and a signal to a taste decrease. Study 2 then examines the contingency variables that moderate the opposing influences of the package cue. Studies 3a and 3b extend these mechanisms to product characteristics and test our framework for more and less healthy products (inter-product comparison). Finally, Study 4 manipulates the healthiness dimension for the very same product (intra-product comparison).

E.1 – Light and pale colors in food packaging: When does this package cue signal superior healthiness or inferior tastiness?

Table 1. Overview of the main objectives and the study stimuli.

| | Study 1a | Study 1b | Study 2 | Study 3a | Study 3b | Study 4 |
|-------------------------|--|--|--|--|--|---|
| | <i>Light-colored package's role of a subtle health cue or a signal to a taste decrease</i> | | <i>Moderation of the opposing color effects</i> | <i>Package color effects for more and less healthy products (inter-product comparison)</i> | | <i>Interplay with other health cues (intra-product comparison)</i> |
| Objective | Associative linkage: light-colored packages ↔ healthy (health effect) / less tasty (taste effect, H ₁) | Choice of light-colored packages when different goals are active | Taste and health effects depending on the presence of the sensory cue (H ₂) and health consciousness (H ₃) | Dominance of the negative taste effect for a less healthy product | Dominance of the positive health effect for a more healthy product | Manipulation of product healthiness for the same product, non-linearity of color lightness effects |
| Method | Implicit association test | Observational experiment (indulgence vs. health framing) | 2 (color lightness) × 2 (sensory cue) experiment | 2 (color lightness) × 2 (sensory cue) experiment | 2 (color lightness) × 2 (sensory cue) experiment | 3 (color lightness) × 2 (color) × 2 (type of product) experiment |
| Light-colored packaging | Stimuli of Studies 2 to 4, and pale packages of pizza, chocolate, and yoghurt |  |  |  |  |  (blue condition) |
| Regular packaging | Stimuli of Studies 2 to 4, and regular packages of pizza, chocolate, and yoghurt |  |  |  |  |  (green condition) |
| Dark packaging | - | - | - | - | - |  (blue condition) |
| Colors | Blue, green, red, turquoise | Brown | Green | Red | Red | Blue, green |
| Product(s) | Pizza, chocolate, yoghurt, cream cheese, potato chips, fruit bar, juice | Cereal bar (chocolate flavor) | Cream cheese (herbs flavor) | Potato chips (red paprika flavor) | Fruit bar (red fruits flavor) | Orange juice |

3 Preliminary studies 1a and 1b: role of a health cue

Studies 1a and 1b aim to substantiate our basic premise that shoppers intuitively perceive pale packaging as a health cue. This stage also tests the opposing taste effect of our framework.

3.1 Study 1a: Subtle associative linkage between light tones and health or taste perceptions

3.1.1 Procedure and materials

Since color-induced inferences may be activated spontaneously and operate outside conscious awareness, we applied a less obtrusive technique, the widely-applied implicit association test (IAT, Greenwald, McGhee, and Schwarz 1998). The IAT is a computer-based reaction-time measurement that assesses heuristic associations between target concepts and evaluative attributes. Across seven blocks, the task is to categorize stimuli from different categories that are presented in the center of the screen. In the first block, subjects classify pictures of light-colored and darker food packages into the respective categories (shown in the upper corners) by pushing one of two keys (E and D). To draw stimuli for both conditions, graphic designers manipulated the lightness of eight packages (Table 1), five of which are used in the Studies 2 to 4. All other parameters (hue and saturation) and elements of the packaging (size, shape, pictures, etc.) were held constant. We used different colors as well as healthy and unhealthy product categories to increase generalizability. In a second block, the subjects allocated word stimuli for the attributes “healthy” (e.g., fit, lively, well, vivid) and “unhealthy” (e.g., sick, ill, harmful, excessive, unwell). In a third and fourth critical test block, the stimuli of the target concepts *and* the attributes are grouped together (e.g., left side of the screen: “light-colored packaging *or* healthy”). The positions of the target concepts were switched and practiced in block 5. Blocks 6 and 7 again presented target concepts and attributes together, yet with the opposite pairing as in blocks 3 and 4 (“light-colored packaging *or* unhealthy”). In total, the procedure contained 180 trials. Since subjects are asked to complete the tasks as fast as possible while avoiding mistakes, the IAT taps into associations that are activated intuitively and without greater effort. The strength of the heuristic association is reflected in the difference between mean response times for the critical test blocks 3 and 4 and the opposite pairing (blocks 6 and 7). Faster responses in the hypothesis-consistent (vs. inconsistent) condition imply that consumers associate light tones of the package more closely with healthy.

The participants also completed a second IAT measuring taste associations. The IAT protocol and the stimuli were the same with the slight difference that eight word stimuli were used which are associated with the labels “tasty” (e.g., delicious, yummy, appetizing, appealing) and “not tasty” (e.g., bland, flavorless, disliked, unsavory). To rule out method artefacts, the order of both IATs as well as the order of compatible and incompatible task conditions were balanced. Forty-six subjects (29.2 years, $SD = 7.9$, 49% female) completed this procedure (all experiments we report herein recruited German participants). Error rates are low for both IATs (9.7% and 8.2%, respectively). Four subjects finished only one of the two IATs.

3.1.2 Results and discussion

Regarding heuristic healthiness associations, mean response latencies clearly show that the subjects have fewer difficulties to pair light-colored (vs. regular) product packaging with healthy, because response times were slower for the incompatible pairing ($M_{\text{incompatible}} = 1,156.51$ ms vs. $M_{\text{compatible}} = 845.66$ ms). Bear in mind that the stimuli included the very same product packages that differed in color lightness only. The calculated IAT D-score (Greenwald, Nosek, and Banaji 2003) is strong ($M_{\text{D-Score}} = .71$, $SD = .40$) and significant ($t(44) = 12.119$, $p < .001$). Thus, light-colored packages are largely considered a health cue (95.6% had positive D-scores) and the IAT confirms the relatively automatic nature of reliance on this package cue. For taste associations, the second IAT effect did not reach significance ($M_{\text{D-Score}} = .07$, $SD = .58$, $p > .05$; $M_{\text{compatible}} = 949.06$ ms vs. $M_{\text{incompatible}} = 995.21$ ms; 56% positive D-scores). A relatively wide range of D-scores (-1.23 to 1.48) indicates that intuitive taste associations with pale packages are heterogeneous and, presumably, depend on further factors (which is tested for in the subsequent studies).

A second goal of Study 1a was to test the stimulus materials that are used in the main experiments (Studies 2-4). To this end, we isolated the trials that showed the respective picture stimuli. A reanalysis of the reaction times reveals that all packages in lighter tones were paired with healthiness much faster than with unhealthiness (and vice versa for the regular version). The differences in reaction times are significant for the five manipulated food packages (Table 2).

Table 2. Mean reaction times for the products that are used in the main experiments.

| | Light-colored package paired with | | | | Regular package paired with | | | | |
|--------------------------------|-----------------------------------|-----------|-----------|----------|-----------------------------|-----------|----------|----------|-----|
| | healthy | unhealthy | t-value | <i>p</i> | healthy | unhealthy | t-value | <i>p</i> | |
| <i>Study 2</i> (Cream cheese) | 850.7 ms | 1181.6 ms | -3.473 | *** | 1158.6 ms | 869.5 ms | 3.966 | *** | |
| <i>Study 3a</i> (Fruit bar) | 722.1 ms | 1108.0 ms | -6.560 | *** | 1061.2 ms | 784.2 ms | 5.569 | *** | |
| <i>Study 3b</i> (Potato chips) | 800.2 ms | 1043.0 ms | -2.857 | ** | 1018.2 ms | 802.9 ms | 3.491 | *** | |
| <i>Study 4</i> (Orange juice) | green label | 965.4 ms | 1359.0 ms | -4.187 | *** | 1164.6 ms | 749.1 ms | 5.808 | *** |
| | blue label | 871.2 ms | 1150.7 ms | -4.927 | *** | 1051.5 ms | 697.8 ms | 5.962 | *** |

Notes. t-test, level of significance: ** $p \leq .01$, *** $p \leq .001$.

3.2 Study 1b: Opposing package color effects on actual food choices

Having revealed that light-colored packaging is associated with healthiness, a second preliminary study aims to show how this affects decisions in a real consumption context. Study 1b observes actual choices between two cereal bars (chocolate flavor) from two packages with different color intensity. To test the proposed theory of the ambivalent meanings of light-colored packages, we manipulated the consumption framing (health vs. indulgence). The opposing inferences from the package cue should depend upon which goal is activated (Deval et al. 2013). We expect individuals to favor products from the light-colored packaging when the health goal is salient, whereas they should prefer the darker packaging under an indulgence framing.

3.2.1 Procedure and materials

Participants were randomly assigned to one of the two conditions (health vs. indulgence). This study consisted of two steps. The first step activated the framing. To induce the respective mindset, the participants were asked to remember a situation in which they (i) experienced something absolutely delicious or (ii) experienced themselves as absolutely healthy. They were then asked to describe this moment with one or a few words and to write down their thoughts. In the second step, they could take a cereal bar as a small reward for their participation (“When looking for something healthy/tasty, which of the two cereal bars would you choose?”). The two packages were displayed on a table and their positions were interchanged randomly. In total, each version was on the right-hand side for half the duration of the experiment. The cereal bars were placed in front of the respective packages, covered by a lid (the product was the same for both options). Thus, the subject’s choices were primarily based on the packaging. Brown was chosen as the package color, which corresponds well with the product’s chocolate flavor. It is important to note that we changed color lightness of the packaging only (hue and saturation were held constant). Eighty-four subjects participated (21.4 years, $SD = 2.7$, 52 males).

3.2.2 Results and discussion

Logistic regression analysis confirms a strong influence of the primed goal on the choice of the product with light-colored packaging ($B_{\text{health}} = 2.255$, $\text{Wald} = 7.251$, $\text{Exp}(B) = 9.533$, $p < .01$). Figure 2 illustrates this effect. When the indulgence goal was active, participants chose the cereal bars of the pale (vs. regular) package less often ($\chi^2(1, 42) = 12.302$, $p < .001$). They favored this product, however, when a health goal was active ($\chi^2(1, 40) = 10.756$, $p < .001$). The participant's gender had no main effect on the choices ($B_{\text{male}} = -.612$, $\text{Wald} = .138$, $p > .05$) and did not moderate the goal framing effect ($B = .181$, $\text{Wald} = .029$, $p > .05$).

Study 1b demonstrates that pale packages affect actual product choices. The results confirm our assumption that package color intensity has ambivalent meanings depending on the consumption goal. For both males and females, products with light-colored packaging were preferred when pursuing a health goal, whereas they were avoided when an indulgence goal was active.

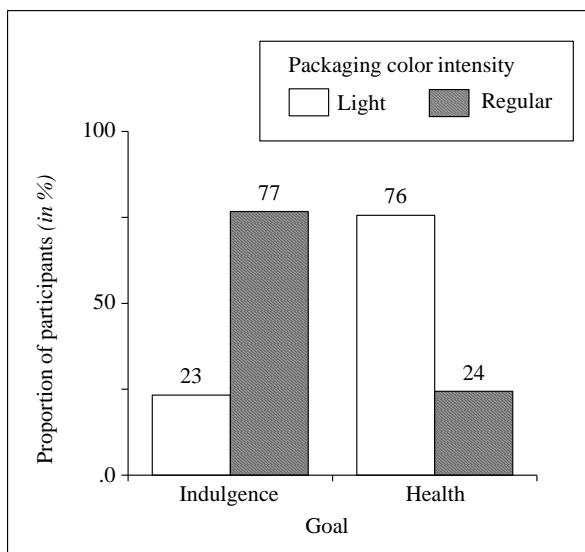


Fig. 2. Choice of the cereal bar with regular vs. light-colored packaging by primed goal.

4 Study 2: Moderation of the opposing package color effects

4.1 Objective

Having demonstrated the role of a subtle health cue, the objective of Study 2 is to investigate the contingency variables that moderate the opposing effects of pale packages. An experiment tests how the need to form taste inferences (i.e., the accessibility of sensory information) moderates the positive taste effect and the negative health effect. It is further explored how these effects differ depending on the shopper's health goal (i.e., the level of health consciousness).

4.2 Materials

Building on exploratory interviews, herb cream cheese was selected as the focal product. Package color was varied in two levels: light green and regular green. Green packaging was used because green is often associated with naturalness and herbs, the product's flavor. A professional graphic design company created the materials (Table 1). To ensure ecological validity, the design was inspired by a real cream cheese brand, but all major elements (e.g., brand name) were fictitious. In the experiment, none of the subjects confused the stimulus with existing brands. Successful manipulation was checked in a qualitative pretest with seven subjects who perceived the stimulus as highly realistic. In both treatment conditions (light vs. regular), the packaging contained the same standard herb cream cheese, which is important for the sensory perception task.

4.3 Procedure

Study 2 applies a mixed-design experiment involving a 2 between-subjects (color lightness) x 2 within-subjects (accessibility of sensory information) design. As regards the color lightness factor, participants were randomly allocated to one condition (light vs. regular green). Note that the subjects were exposed to one product only. This is a very conservative test of our theory because contrasting a pale with a darker version – such as in Studies 1a and 1b – might inflate effect sizes. We manipulated the within-subjects factor (sensory information) by splitting the experiment into two rounds. The first round simulated an in-store situation in which the subjects were shown the package, but they did not taste the actual product. As a cover story, the subjects were told that the study evaluates the market potential before launching the product. They were then asked to evaluate certain food properties (e.g., taste) and to indicate their intent to purchase. Next, a short, unrelated task distracted the subjects. In the second round, we simulated a post-purchase consumption situation in which oral sensory information was accessible. Participants were asked to look at and taste the product using a white plastic spoon (neutral taste). They evaluated the same variables as in the first round. As the packaging contains red and mostly green elements, the Ishihara color test controlled for red-green color deficiencies. None of the subjects failed the test. Finally, we thanked and debriefed the participants. The procedure took between 12 to 15 minutes.

4.4 Measures

A questionnaire measured the subject's purchase intention using a two-item seven-point Likert scale ("I would buy this product.", "Next time I buy cream cheese, I will buy this

product”; $M_{\text{round 1}} = 4.33$, $\alpha = .88$; $M_{\text{round 2}} = 4.87$, $\alpha = .95$). From Mai and Hoffmann (2015), we took a two-item seven-point semantic differential scale to assess food tastiness (“tasty/less tasty”, “enjoyable/not enjoyable”; $M_{\text{round 1}} = 4.53$, $\alpha = .70$; $M_{\text{round 2}} = 5.07$, $\alpha = .82$) and a three-item seven-point semantic differential scale for food healthiness (“healthy/unhealthy”, “helps/does not help me to stay fit”, “helps/does not help me to stay slim”; $M_{\text{round 1}} = 4.42$, $\alpha = .77$; $M_{\text{round 2}} = 4.21$, $\alpha = .84$). To assess pursuit of an overarching health goal, we used a domain-general measure that is unrelated to health or nutrition. This helps to avoid an inflation of effects. A four-item seven-point Likert scale was adopted from Gould’s (1988) Health Consciousness Scale to assess the level of health consciousness (e.g., “I reflect about my health a lot.”; $M = 5.04$, $\alpha = .83$).

Since food decisions are driven by a whole host of factors, we measured several control variables: age, gender, education, liking of cream cheese, diet-product consumption, favorite color and the importance of extrinsic cues when shopping (brand, shape and color of packaging).

4.5 Sample

In all, 179 individuals participated in the experiment. Recruitment was done through direct and indirect sampling methods. Participants were contacted personally by one of the authors or they were recruited via referrals (e.g., from initial subjects). This approach helped to cover a relatively large regional territory including major cities and smaller towns in the Eastern part of Germany. In this way, we avoided urban-rural discrepancies concerning food heritage, food attitudes or differences concerning food store density. Quota sampling was further applied to include a wide range of characteristics regarding age, gender, and occupational background. On average, participants were 38.7 years ($SD = 15.4$, ranging from 13 to 79 years), and 53% were female.

4.6 Results

4.6.1 Moderating role of the need for heuristic taste inferences (availability of sensory information)

The first step of the analysis examines the first proposed contingency variable. The analysis tests if the effects of package color are dependent on whether oral sensory information is absent or present. Mixed-design ANOVA was conducted with package color as the between-subjects factor and the evaluations of tastiness and healthiness as the within-subjects dependent variable.

For the situation when tasting was not possible (visual inspection only), the analysis reveals a strong interaction effect between both factors ($F(1, 177) = 6.991, p < .01$). As shown in Figure 3, the subjects drew opposing conclusions from the package cue. The product with regular green was rated more tasty than healthy, whereas the product with the light-colored packaging was perceived relatively healthier than tasty. According to our theory, we would expect that these opposing inferences are passed along to the purchase decision. Regression analysis reveals that only the taste evaluations guide the purchase intention (taste: $\beta = .46, t = 6.475, p < .001$; health: $\beta = .04, t = .496, p > .05$). Next, we tested for multiple mediation. We applied the Preacher-Hayes (2004) bootstrapping procedure (10,000 samples) and the PROCESS macro (Hayes 2013), using color intensity as the dummy-coded independent variable (light-colored package = 1, regular = 0), the taste and health evaluations as the mediating variables, and purchase intention as the dependent variable. The results reveal that the negative indirect effect (IE) of light-colored packaging via taste evaluations (IE = $-.10$) is marginally significant (90% confidence interval $CI_{90} = -.01$ to $-.23$), whereas the positive indirect effect through healthiness is not significant (IE = $.01, CI_{90}$ includes 0). Thus, the package cue's taste effect outweighs the health effect in this situation.

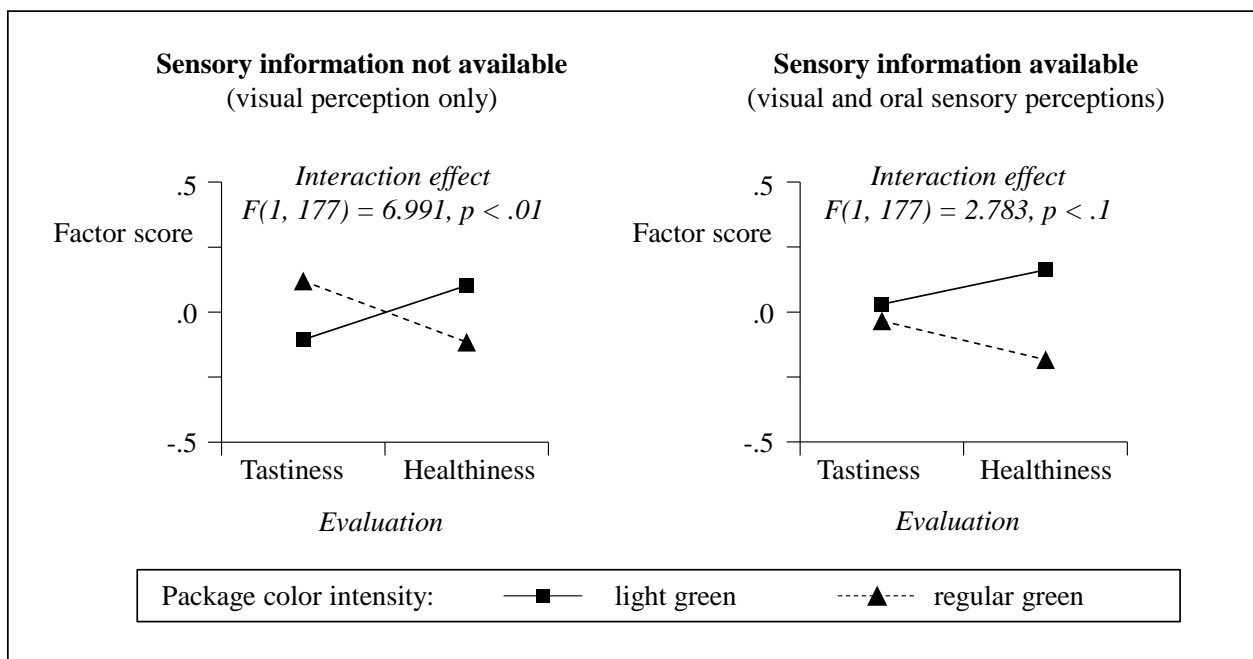


Fig. 3. Tastiness and healthiness evaluations depending on packaging color in different consumption situations.

Also for the situation when sensory properties were accessible through tasting, mixed-design ANOVA reveals a marginal interaction effect ($F(1, 177) = 2.783, p < .1$), but the means suggest a different pattern (Figure 3). Evidently, light tones activated primarily

health inferences. That is, health evaluations of the pale packaging surpass that with regular colors ($t(177) = 2.341, p < .05$), but we observed no differences for taste ($p > .05$). Yet, mediation analysis reveals that these health inferences do not impact the purchase decision ($IE = .03, p > .05$), because taste remains the dominant driver (taste: $\beta = .55, t = 8.404, p < .001$; health: $\beta = .09, t = 1.304, p > .05$).

These observations confirm our assumption that the different color-induced inferences are more or less powerful depending on the shopper's need to make heuristic taste inferences. This provides support for H_1 and $H_{2a/b}$. One result is noteworthy, however. The positive health effect did not approach significance and presumably depends on the second contingency variable.

4.6.2 Moderating role of a health goal (health consciousness)

In the next step of the analysis, we are primarily interested in whether the taste effect is weaker for subjects who are motivated to achieve and maintain a good state of health. Conversely, the health effect should be pronounced because such health-conscious shoppers may rely more on health inferences based on package color. We applied the Preacher-Hayes bootstrapping procedure to test if the color effects via taste and health are moderated by health consciousness. Table 3 shows the estimated conditional indirect effects at different levels of health consciousness (10th to 90th percentile). The full ANOVA models are provided in the Web Appendix.

When sensory information was not available, particularly the purchase intentions of the less health-conscious subjects were driven by package color's taste effect. The indirect effect was still marginally significant for those with average health consciousness, but turns nonsignificant for more health-conscious subjects (above the 50th percentile). Regarding the health effect, purchase intentions were not driven by health inferences, irrespective of the level of health consciousness.

However, when having tasted the product, health consciousness strengthened the health effect of package color. This positive influence of pale packages occurred primarily for the health-aware individuals, but not for those who are less concerned about their health. Additionally, the package cue's indirect effect via taste inferences is qualified by the level of health consciousness.

The conditional indirect effects reported above are based on the estimated regressions. To double-check the opposing patterns, we conducted an alternative sensitivity analysis. We ran a tertiary split according to the subject's health consciousness and conducted mul-

multiple mediation analyses (Table 3). The pattern is very robust, supporting H_{3a} and H_{3b}. Furthermore, as food purchase decisions are guided by a multitude of determinants, we further included the control variables and reran all analyses. The results remain stable and several relationships are even stronger.

Table 3. Conditional indirect effects of light-colored packages on purchase intention through the mediators (tastiness, healthiness) at different levels of health consciousness.

| Spotlight Analysis | | Evaluation when sensory information is | | | | | | | |
|--------------------------------------|-------------------------|--|--------------|-------------|----|-----------|--------------|-------------|--------------|
| | | not available | | | | available | | | |
| | | Tastiness | | Healthiness | | Tastiness | | Healthiness | |
| Mediators | IE | BS | IE | BS | IE | BS | IE | BS | |
| Percentiles for health consciousness | | | | | | | | | |
| | 10 th | -.27 | ^a | -.01 | | -.25 | | -.01 | |
| | 25 th | -.17 | ^a | -.00 | | -.08 | | -.00 | |
| | 50 th | -.10 | ^b | .01 | | .04 | | .03 | |
| | 75 th | -.04 | | .03 | | .13 | | .10 | ^a |
| | 90 th | .00 | | .06 | | .18 | ^b | .20 | ^a |
| Tertiary split | | Evaluation when sensory information is | | | | | | | |
| | | not available | | | | available | | | |
| | | Tastiness | | Healthiness | | Tastiness | | Healthiness | |
| Mediators | IE | BS | IE | BS | IE | BS | IE | BS | |
| Health consciousness | | | | | | | | | |
| | low (n=59, M=3.78) | -.32 | ^a | -.01 | | -.29 | | -.00 | |
| | moderate (n=58, M=5.05) | -.03 | | -.02 | | .03 | | .06 | |
| | high (n=62, M=6.23) | -.02 | | .03 | | .20 | ^b | .12 | ^a |

Notes. IE... indirect effect, BS... bootstrapping (10,000 samples), the conditional indirect effect for tastiness (post-consumption) has to be interpreted with caution due to heterogeneity of regression slopes. When accounting for the tastiness × color intensity term, the conditional indirect effects remain stable (e.g., tertiary split analysis, low = -.24 and moderate = .02, $p_s > .05$; high = .12, $p = .1$).

^a 95%-CI ≠ 0, ^b 90%-CI ≠ 0.

4.7 Discussion

Study 2 corroborates our premise that light-colored packaging can be a double-edged sword because this package cue conveys different meanings. Evidently, two types of inferences about pale packages coexist, with opposing implications for product evaluation (and in turn sales).

The experiment has two more specific findings. First, color-induced inferences depend on the need for inferential judgments about taste. Given that taste is an experience quality, the detrimental taste associations were particularly influential when the shopper's taste judgments were solely based on the visual perception of this visual cue. Having experienced the product, however, taste is no longer a missing attribute. Accordingly, the participants relied less on this cue for their tastiness evaluations. Unlike taste, healthiness is a credence quality. Since human abilities are too limited to distinguish more or less healthy products by taste (Hoppert et al. 2012b), food shoppers still have to employ heuristic processing. As a consequence, healthiness evaluations were guided by package color even after the consumer had

tried the product.

Secondly, the dilemma of pale packaging is qualified by consumer characteristics. While Study 1b shows that the contextual framing drives the inferential implications of the package cue, Study 2 extends this finding by showing that even internal factors can serve in this moderating role. A particular inferential tendency (indulgence vs. health-related) is also chronically activated by the shoppers' experiences and attitudes, such as their motivation to maintain a good state of health. Accordingly, light tones are beneficial in two respects when selling to consumers who pursue a health goal. If sensory properties are not accessible, the detrimental taste effect on purchase intention disappears, whereas the positive health effect is strengthened. After having tasted the product, we even observed a marginally positive effect operating through tastiness. On the other side of the coin, pale packaging signals a loss in taste for those who are less health-aware. For these consumers, the health effect is dampened, whereas the negative taste effect is enhanced and dominates the purchase decision. In Study 2, we focused on aspects of the consumer that determine whether package color is interpreted under a health or an indulgence goal. The following studies emphasize characteristics of the product that may boost the salience of these goals.

5 Studies 3a and 3b: Dependency on product healthiness (inter-product comparison)

5.1 Objective

The differential color intensity effects in Study 2 may be specific to the focal stimulus. This possibility merits attention because the impact of package design elements was found to differ between healthy and unhealthy products (e.g., Deng and Srinivasan 2013). Since the opposing inferences from a given cue depend on which goal is salient and, in turn, which inference rule is applied (Deval et al. 2013), healthier products might make the health-related inference rule accessible. This should boost package color's positive health effect. Conversely, unhealthy products are often consumed for pleasure and indulgence. The indulgence inference rule should be accessible for such products enhancing the negative taste effect. Consequently, the type of product may determine what conclusions consumers draw from package color intensity. Two studies therefore examine the differential color intensity effects for a less healthy product (potato chips) and a healthier product (fruit bars) of the product category snacks.

5.2 Experiment 3a: Less healthy product variants enhance the negative taste effect

Study 3a examines a product that is typically consumed for indulgence rather than for staying healthy. For such products, consumers are expected to place emphasis on taste, whereas health benefits are less relevant. Hence, it is plausible that the health effect of color intensity is weak (if present at all), so that consumer judgments are primarily shaped by the cue's taste effect.

Potato chips (red pepper flavor) were selected as the focal product.⁷ A red packaging of a fictitious brand that fits the product's flavor was developed. The packaging was manipulated to create the two experimental conditions (Table 1). The study applies the same protocol and measurements as in Study 2. The experiment was conducted at the entrance to the cafeteria of a larger university. Two-hundred and six consumers (28.8 years, $SD = 10.58$, 51% male) evaluated the product (regular or light-colored packaging) before and after tasting.

As in Study 2, we firstly examined the interplay of color and sensory perceptions. Mixed-design ANOVA with color intensity (between-subjects), the availability of sensory information (within-subjects) and the tastiness/healthiness judgments reveals an interaction effect among these factors ($F(1, 204) = 7.056, p < .01$). When including health consciousness, this effect is further qualified by the level of health-consciousness ($F(1, 202) = 5.126, p < .05$).

To facilitate the interpretation of this interplay, we spotlight the two consumption situations. When oral sensory information is missing, Study 3a confirms the disordinal interaction effect ($F(1, 204) = 2.987, p = .09$) that was observed in Study 2 (Figure 4). Multiple mediation analysis tested for the conditional indirect effects via health and taste impressions. Again, the analysis reveals a negative taste effect particularly for the less health-conscious subjects (1SD below the mean of health consciousness: $IE = -.21, CI_{95} \neq 0$), but not for the more health-conscious subjects (mean: $IE = -.10$; +1SD: $IE = .02, CI_{95} = 0$). No significant indirect effects via health associations were observed, however (CIs include 0, Figure 4). This must be attributed to the fact that purchase intentions were solely driven by judgments about tastiness (before: $\beta = .62, t = 11.109, p < .001$; after: $\beta = .57, t = 9.875, p < .001$), not about healthiness (both $ps > .05$).

In the situation when sensory properties were accessible through tasting, there is no significant interaction effect between the taste/health evaluations and color intensity ($F(1, 204) = .612, p > .05$). Although health consciousness raised health perceptions of pale

⁷ We used regular potato chips because other variants can be positioned as relatively healthier (e.g., baked chips).

packages ($\beta = .16$, $t = 2.258$, $p < .05$), the indirect health effect did not reach significance. Evidently, for this type of product, health benefits (or lack thereof) are not reflected in the intent to purchase. Notably, having tasted the product, the indirect taste effect is reversed for the less health-conscious subjects. Tasting seems to counteract unfavorable taste expectations that are conveyed by pale packages.

Thus, for a product that is typically consumed for pleasure and indulgence, Study 3a shows only the negative implications of pale packages. As in Study 2, the purchase intentions of the less health-conscious consumers were partially shaped by unfavorable taste expectations when sensory experiences were missing. Albeit the more health-aware consumers interpreted this as a health cue especially after tasting, the health impressions were irrelevant for the final purchase decision. This supports the thesis that the positive health effect is mitigated for a less healthy product.

5.3 Experiment 3b: More healthy product variants enhance the positive health effect

Study 3b examines a variant of the category snacks that is positioned as rather healthy. We manipulated the packaging of a fruit bar (Table 1). The experiment was similar to Study 2, with one exception. In Study 2, the same subjects first evaluated the product before consumption and then after. It is possible that the observed differences are artificially elevated due to carry-over effects. To rule out this possibility, the accessibility of sensory information is manipulated between subjects.⁸ To demonstrate differential reliance on package color, the subjects evaluated the product only once (with or without tasting). One-hundred and twenty-five participants (23.2 years, $SD = 3.50$, 64% male) completed the procedure at the entrance to the cafeteria of a university.

First, we assess the moderating influence of sensory perceptions. Mixed-design ANOVA with the two experimental factors color lightness (light vs. regular) and sensory information (missing vs. accessible) as well as the dependent variable (taste and health evaluations) reveals a marginal interaction among these factors ($F(1, 121) = 3.302$, $p = .07$). As shown in Figure 4, the pattern is opposite to the observations of Study 3a. While pale packages are perceived marginally healthier than regular packages when the sensory cue is hidden ($t(58) = 1.668$, $p = .1$, taste: $p = .7$), light-colored packages are perceived tastier when the participants were able to taste the product ($t(57) = 1.707$, $p = .09$, health: $p = .9$). Yet, only the taste impressions guide the intent to purchase (sensory information missing: $\beta = .63$,

⁸ The authors are grateful to an anonymous area editor for drawing their attention to this issue.

$t = 6.110$; accessible: $\beta = .61$, $t = 6.182$, both $ps < .001$). The impact of healthiness evaluations did not approach significance ($ps > .05$).

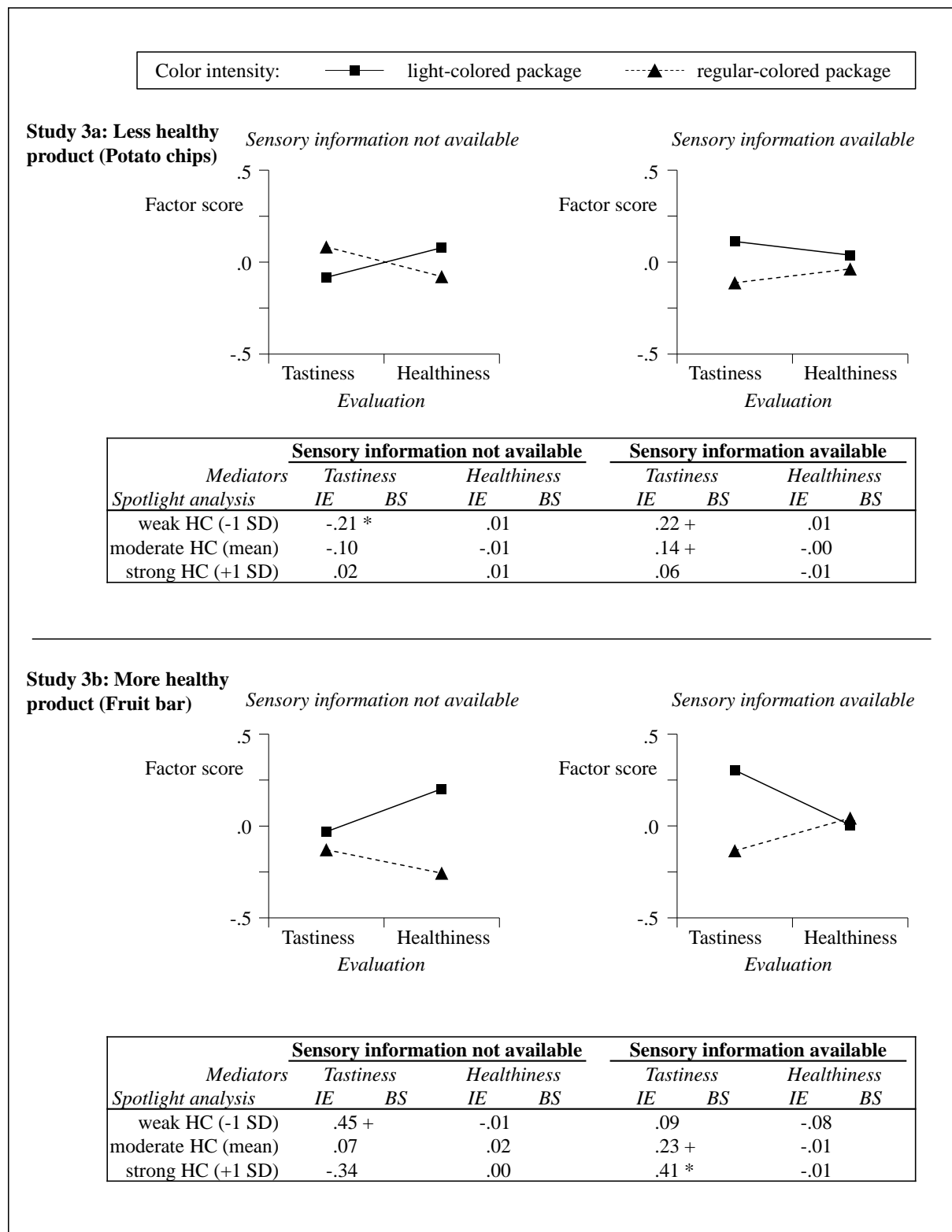


Fig. 4. Tastiness and healthiness evaluations as a function of package color and the availability of the sensory information for less (Study 3a) and more healthy products (Study 3b).

Notes. IE indirect effect, BS bootstrapping (10,000 samples), HC health consciousness, * 95%-CI $\neq 0$, + 90%-CI $\neq 0$.

Moderated mediation analysis further reveals that the indirect effects via color-induced taste associations are contingent on health consciousness. When sensory perceptions were not accessible, light-colored packages elicited favorable taste expectations that were translated into purchase intention more often for the less health-conscious subjects (-1SD below the mean: IE = .45, CI₉₀ ≠ 0) than for the more health-concerned individuals (+1SD: IE = -.34, CI₉₀ = 0). By contrast, when tasting was possible, these positive indirect taste effects occurred primarily for the more health-conscious consumers (+1SD: IE = .41, CI₉₅ ≠ 0; -1SD: IE = .09, CI₉₀ = 0).

Overall, Studies 3a and 3b support the notion that the consumption timing and consumer health consciousness moderate the effects of package color intensity. In line with Study 2, the cue's impact varies, especially in terms of taste evaluations. This is an important finding because influencing taste perceptions is not the primary targeted attribute when pale packaging is applied as a health cue. As expected, light-colored packages have particularly unfavorable implications when the type of product is typically consumed (and evaluated) under an indulgence inferential rule (Study 3a). For a healthier option (Study 3b), light tones have more favorable implications, even for perceived tastiness. In this research, product (un)healthiness was hitherto examined across different products (inter-product variability). Study 4 manipulates this attribute for the very same product (intra-product variability). Additionally, the previous studies contrast a light-colored packaging with regular packaging. Yet, color effects may depend on the color intensity of the counterpart. To test for nonlinearity, Study 4 varies color lightness in more than two degrees.

6 Study 4: Dependency on product healthiness (intra-product comparison)

6.1 Objective

In the previous stages, color effects were examined across different products and colors. The observed differences imply that product healthiness primes the interpretation of light tones as a health (or taste) signal. In a similar manner, health associations that are activated by certain types of colors may determine what conclusions consumers draw from pale packages. Consequently, reliance on light tones as a health cue seems more likely when other diagnostic attributes support this mental shortcut (Lynch, Marmorstein, and Weigold 1998; Naylor, Droms, and Haws 2009). Contrariwise, inconsistent inputs detract from perceived diagnosticity and, under the worst condition, the subtle health cue is not taken into consideration. To test this assumption, Study 4 manipulates perceived healthiness of the product and

the color for the very same product (intra-product comparison). In addition, the magnitude of package color effects may depend on the respective counterpart. We therefore contrast pale packages with a more and a less dark variant.

6.2 Procedure and treatment

In a 3×2×2 experiment, we manipulated the between-subjects factors color intensity (light, regular, and dark), type of color (associated with healthy vs. neutral), and type of product (associated with healthy vs. conventional). We applied the protocol of Study 2 with one exception. Since package color's detrimental taste effect proved particularly strong when oral sensory information was hidden, Study 4 focuses on this situation. Orange juice by a fictitious brand was selected as the focal product.⁹ Building on exploratory interviews, the color of the product's label was either green (associated with healthy nutrition) or blue (perceived neutral). As regards product type, the label indicated that the product was either pure squeezed juice (associated with healthy) or juice from concentrate (conventional). Color intensity was manipulated by changing the lightness values in such a way that the visual appearance is similar for green (values = 102, 69, and 25) and blue tones (182, 98, and 50). Again, hue and saturation values were held constant. The manipulated labels were affixed to glass bottles with brass-colored caps. All bottles contained regular orange juice. A qualitative pretest (ten subjects) confirmed ecological validity of the stimulus.

The participants assessed product healthiness ($M = 5.07$, $\alpha = .75$; e.g., “healthy/unhealthy”, “calorie-rich/poor”) and tastiness ($M = 5.16$, $\alpha = .93$; e.g., “tasty/less tasty”, “enjoyable/not enjoyable”) with four-item seven-point semantic differential scales. They also indicated their purchase intentions using a three-item seven-point Likert scale ($M = 4.44$, $\alpha = .90$; e.g., “Next time I buy orange juice, I will buy this product”) and we measured several control variables (e.g., liking of orange juice, age, gender).

Based on quota sampling (age and sex), subjects were recruited in city centers, shopping malls, and public places of four larger German cities. In all, 246 consumers participated, with the average age being 43.9 years ($SD = 18.6$, 59% were female). Six subjects had to be excluded because of red-green color deficiencies. No incentives were offered to participants.

⁹A detailed description of the manipulation and the wording of the measurements are provided in the Web Appendix.

6.3 Results and discussion

A manipulation check confirms successful manipulation because the pure squeezed juice variant (vs. juice from concentrate, $t(238) = 4.586, p < .001$) and the green labels (vs. blue, $t(238) = 3.585, p < .001$) were perceived healthier. Mixed-design ANOVA examined the interplay of the three between-subjects factors and the evaluation of taste and healthiness (within-subjects variable). The analysis reveals interaction effects between the taste/healthiness evaluations and each experimental factor (color intensity: $F(2, 228) = 4.463, p < .05$; type of color: $F(1, 228) = 4.766, p < .05$; type of product: $F(1, 228) = 3.242, p = .07$) (Table 4). As regards color intensity, paired t-tests show that light-colored labels were perceived relatively healthier than tasty ($\Delta M = -.16$) and that this difference is marginally significant ($t(79) = -1.710, p_{one-tailed} < .05$). Regular labels were perceived tastier than healthy ($\Delta M = .23, t(79) = 2.153, p < .05$), whereas darker labels were perceived equally healthy and tasty ($\Delta M = -.07, t(79) = -.762, p > .05$). Thus, when comparing the light-colored and the regular version, we observe the same interaction effect as in Study 2 and 3a. Yet, including a darker variant reveals that the color-induced effects are more complicated than originally thought because they are clearly dependent on the darkness of the counterpart.

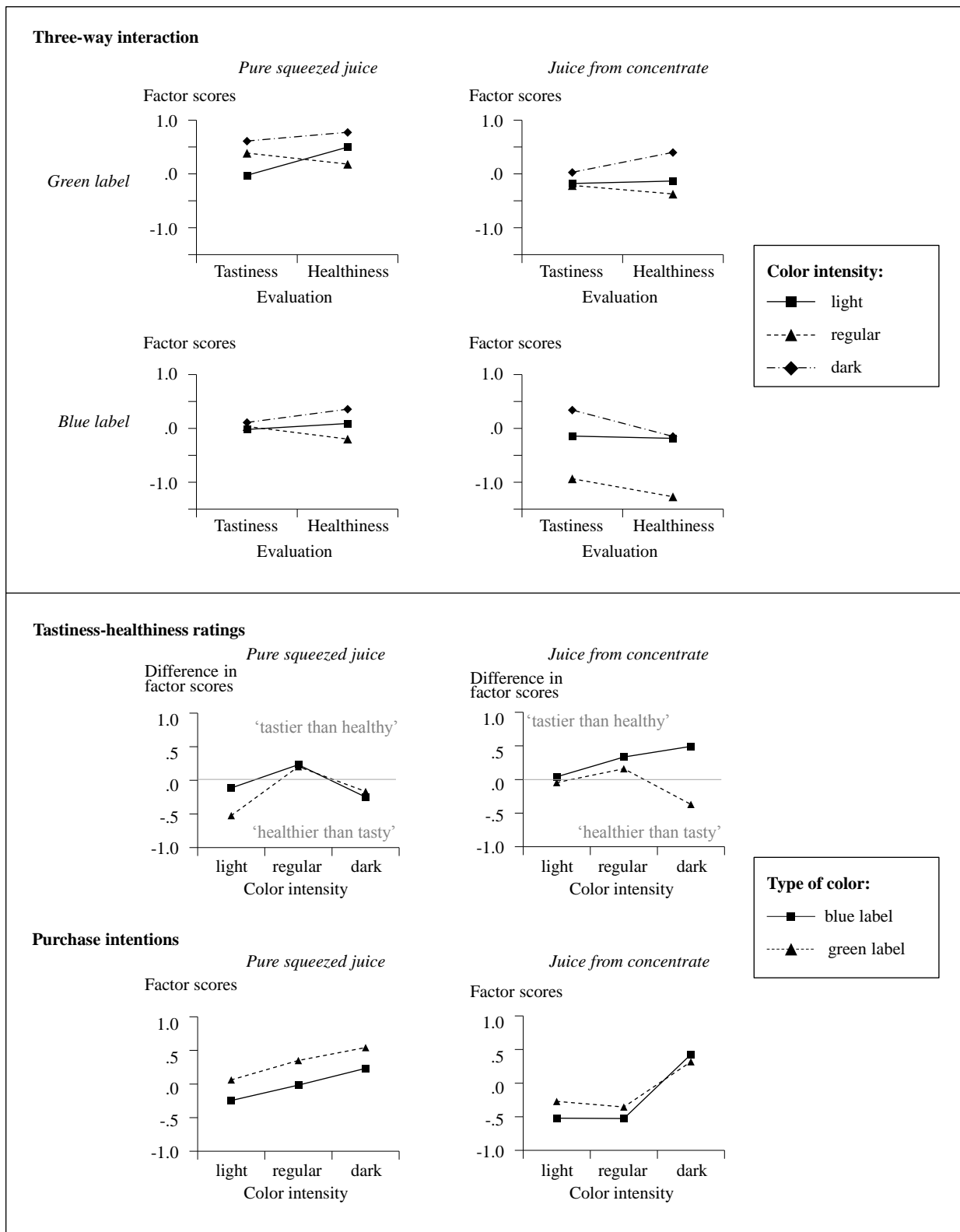


Fig. 5. Tastiness-healthiness inferences and purchase intentions depending on the experimental factors.

The analysis also reveals a marginally significant interaction among all four factors ($F(2, 228) = 2.698, p = .07$). To facilitate the interpretation, Figure 5 plots the means and the taste-health scores. Positive difference scores imply that the product is perceived relatively

tastier than healthy (and vice versa for negative differences). Evidently, the light-colored packages produced the greatest gap between the judgments of health and taste when further cues were accessible that are associated with healthy nutrition (light-green pure juice: $\Delta M = -.52$, $t(19) = -2.800$, $p < .05$). In line with recent research (Deval et al. 2013), light tones are most effective in signaling health benefits when complementary diagnostic input primes the interpretation of this cue by activating a health goal. We also find the opposite consistency pattern when other health cues were absent. The product was perceived most tasty (vs. healthy) for the dark blue-labeled juice-concentrate product ($\Delta M = .49$, $t(19) = 2.120$, $p < .05$). Hence, Study 4 furnishes further evidence for the very same product (intra-product comparison) that the role of a package health cue depends on perceived product healthiness (which enhances salience of a health goal at the time of judgment).

Notably, ANOVA shows substantial main effects of the experimental factors on purchase intentions, but no meaningful interactions (Table 4). In general, the dark packages created greater intent to purchase than those with light or moderate colors (post-hoc test LSD: all $ps \leq .001$). The light and moderate levels did not differ ($ps > .05$). These observations suggest that the color effects are not linear in nature and depend on the (absolute) level of color intensity. As illustrated in Figure 5, it makes a difference whether light-colored packages are contrasted with moderate or darker levels. Thus, care must be taken not to overgeneralize the findings of this research.

Table 4. Differences in tastiness-healthiness ratings and purchase intentions as a function of the manipulated factors.

| | Tastiness | | Healthiness | | Tastiness-healthiness ratings | | Purchase intentions | |
|---|-----------|----------|-------------|----------|-------------------------------|----------|---------------------|----------|
| | <i>F</i> | <i>p</i> | <i>F</i> | <i>p</i> | <i>F</i> | <i>p</i> | <i>F</i> | <i>p</i> |
| Color lightness | 5.124 | ** | 15.159 | *** | 4.463 | * | 9.813 | *** |
| Type of color | 2.796 | + | 15.670 | *** | 4.766 | * | 3.077 | + |
| Type of product | 8.853 | ** | 24.833 | *** | 3.242 | + | 6.245 | * |
| Color lightness × type of color | 1.918 | | 1.102 | | .542 | | .220 | |
| Color lightness × type of product | 2.916 | + | 1.139 | | .620 | | 1.917 | |
| Type of color × naturalness | .405 | | .188 | | 1.280 | | .814 | |
| Color lightness × type of color × type of product | 1.994 | | 1.213 | | 2.698 | + | .182 | |

Notes. ANOVA, level of significance: + $p \leq .1$; * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

7 General discussion

The marketing tools arsenal of food providers contains a vast variety of package elements that are helpful in highlighting product healthiness directly (via health claims, product names, etc.) or in a more subtle manner. This research scrutinized an important and widely

applied visual design element (and supposedly health signal). Previously, it had been unclear when consumers rely on light-colored packaging as a health cue. Footing on seminal research on cue diagnosticity (Lynch, Marmorstein, and Weigold 1998; Naylor, Droms, and Haws 2009), opposing naïve theories (Deval et al. 2013), and competing food evaluation goals (Raghunathan, Naylor, and Hoyer 2006), it was our basic premise that this tool has the potential to backfire because – apart from health inferences – light tones activate less favorable perceptions of another valued attribute.

This research made several contributions to the marketing literature. Across a series of six experiments, we found convergent evidence of the opposing color-induced effects. In this way, we add an important package element to the list of marketing phenomena that have contradicting implications (Deng and Srinivasan 2009; Deval et al. 2013; Mitra and Lynch 1995). Indeed, reaction-time measurement (Study 1a) revealed a strong automatic linkage between light-colored packages and healthiness in the consumer’s mind. Yet, heterogeneous associations with tastiness imply that further factors determine whether pale packaging helps or hurts.

First, the shopper’s goal can modify the color effects because different heuristic inference rules are active at the time of judgment. In Study 1b, pale packages were favored when the long-term utilitarian goal (maintaining a good state of health) was salient, whereas they were avoided when the short-term hedonic goal (indulgence) was active. In line with recent works (Deval et al. 2013), the contextual framing of a marketing cue can elicit opposing implications. We extend this theory by showing that internal factors can also serve in this moderating role. The respective inference rule (taste vs. health-related) can even be activated by a food shopper’s motivation and attitudes (Study 2), but also by product healthiness (Study 3a/b), and other attributes (Study 4). Accordingly, the positive health effect was strengthened when consumers aspire to pursue a healthy lifestyle (Study 2) or when healthier products (Study 3b) and colors (Study 4) prime the interpretation of the package cue. By contrast, light tones were prone to trigger the negative taste effect when health goals were less relevant, such as for less health-conscious consumers (Study 2) or products that are typically consumed for indulgence and pleasure (Study 3a).

Secondly, reliance on package color is further determined by the need to employ heuristic processing. Since tastiness is an experience quality, detrimental taste inferences are primarily triggered when consumers are unable to access sensory properties through tasting. To bridge this gap, shoppers have to refer to extrinsic cues, such as package color. As was shown in Studies 2 and 3a, the negative color-induced taste effect for less health-aware indi-

viduals disappeared after consumption because tastiness is no longer a missing attribute (i.e., food evaluations rest on actual taste experiences). Even more, we were able to observe positive color-induced taste effects for these consumers (Study 3b). Likewise, Studies 2, 3a, and 3b revealed positive taste inferences after tasting. Evidently, color intensity is a key taste cue, but this design element does not necessarily signal a taste deficit. As previous experiences and attitudes serve as a lens through which consumers evaluate food products, positive disconfirmation of package-based expectations (Oliver 1980), expectancy violations, or motivated reasoning (Kunda 1990) may modify the inferential effects, which is consistent with prior research (Piqueras-Fiszman and Spence 2015; Naylor, Droms, and Haws 2009). In this regard, our findings provide another step towards understanding the opposing implications of certain marketing cues and, in particular, product packaging.

Taken together, our research contradicts the conventional wisdom that consumers unconditionally regard light-colored packages as a health cue. Although aiming at a seemingly positive attribute, food companies may unwillingly damage another valued attribute. Owing to the dominance of taste in food decision making, the taste inferences had much greater impact on purchase intentions (Studies 2, 3a, and 3b) than the conclusions about health. Thus, package color's role as a taste cue should be taken into account when deciding to employ light tones as a signal to superior health. The question of whether light tones help or hurt is further determined by motivational factors (health consciousness), the need to apply heuristic processing (tasting possible), and the presence of other diagnostic cues that prime the interpretation of this package cue (product type, color). Neglecting the mechanisms unraveled in this paper could lead to suboptimal conclusions.

Care must be taken not to (over-)generalize the conclusions based on our results (e.g., some results were marginally significant). By distinguishing more than two levels of color lightness, Study 4 has shown that the magnitude and direction of color effects also depends on the intensity of the contrast product. Please note that some marketers misuse color to create the impression of healthiness. For example, in response to the ban of 'light' descriptors on tobacco products, tobacco companies reportedly substituted light colors and color names to reduce risk perceptions and to evade the Food and Drug Administration's regulatory actions (Connolly and Alpert 2014). Promoting such questionable marketing tactics is strictly not intended with this paper.

7.1 Managerial implications

Food providers have to be careful when attempting to promote product healthiness with the help of pale packages because this cue has different meanings to different shoppers in different food retail environments. On the one hand, light tones can be harmful when heuristic processing of this cue is not guided by health goals. Marketers therefore should have knowledge about the target segment's health orientation. When targeting health-unaware shoppers, there is the distinct possibility that the package is regarded as a signal to a taste decrease because these consumers place emphasis on taste (Mai and Hoffmann 2012). When addressing this segment or promoting products that are consumed for indulgence, companies might differentiate the packaging or they may evade unfavorable taste inferences using darker shades (by simultaneously abandoning the benefit of signaling health). On the other hand, light tones have a different meaning to health-concerned shoppers. This segment is more likely to pursue a health goal. As health-conscious consumers are more sensitive to health-related attributes (Gould 1988; Naylor, Droms, and Haws 2009), they are apt to draw conclusions about health benefits. Notably, after having experienced the product, these consumers even seem to align the tastiness dimension to their health goal.

Marketers should consider that unfavorable taste inferences are amplified by one's need to make heuristic inferences. In in-store purchase situations, sensory properties are often hidden, especially in terms of product innovations or food products with which shoppers are unfamiliar. If marketers make tasting possible by product sampling or front cooking, the negative taste effect could be reduced. In this case, shoppers are able to rely on actual sensory experiences, rather than taste heuristics. It is important to stress that characteristics of the product or retail environment prime the interpretation of the package cue. Inconsistencies with other diagnostic cues should be avoided because this weakens the major benefit of communicating superior health.

Our findings also have vital policy implications. References to health benefits should be applied with caution when addressing less health-aware individuals who are the prime target of prevention campaigns. These consumers are less willing to process health information or to follow advice for "good" eating behaviors (Block et al. 2011; Hamilton et al. 2000). Under the worst condition, they develop reactance. Our results corroborate that less health-aware consumers are susceptible to associating a health cue with a lack of taste, especially if this attribute is hidden. Thus, when selling healthy foods to less health-aware shoppers, pale packages can have a deterrent effect, instead of nudging at-risk shoppers towards healthier choices.

Employing darker tones could be a way – among others (Mai et al. 2014) – to compensate for a perceived taste decrease.

7.2 Limitations and future research

This work has some limitations calling for more research. From a conceptual perspective, the paper has identified two key variables to moderate the opposing implications of light-colored packaging. Beyond motivational factors, other consumer characteristics may play a moderating role, such as volitional factors (e.g., self-control; self-efficacy, Bandura 1986) or affective variables (e.g., emotional ability, Kidwell, Hasford, and Hardesty 2015). We have shown that the positive health effect and the negative taste effect depend on the goals that are active at the time of judgment. Other goals may also modify these influences (e.g., social approval, satiation, Suher, Raghunathan, and Hoyer 2016). Intriguingly, Studies 3a and 3b reveal that some subjects even draw positive conclusions about taste, albeit product composition was held constant. Future studies should elaborate on the conditions under which the negative taste effect is reversed because this could be a lever for bridging the (expected) taste deficit of a health cue. Our research builds on the notion that light colors activate heaviness associations through metaphors and symbolic meaning that spill over to healthiness evaluations. Although prior research confirmed this associative linkage for colors (Pinkerton and Humphrey 1974; Karnal et al. 2016; Locher et al. 2005), more research on the underlying mechanisms is needed. To elaborate on the mediating role of heaviness associations, future studies should employ measurements of perceived heaviness (e.g., Deng and Kahn 2009). Finally, colors can have different meanings across cultures (Aslam 2006; Madden, Hewett, and Roth 2000) and food associations vary due to local food heritage (Werle, Trendel, and Ardito 2013). Thus, cross-cultural studies should validate the opposing inferences.

From a methodological standpoint, Studies 2 and 3a/b pinpoint that consumer responses vary considerably between isolated (visual cue only) and multi-sensory research designs (visual and sensory cues). When investigating food decisions, marketing scholars often employ pictures of foods or mock-up packages (e.g., in online studies with MTurk workers). Yet, the results of such designs are limited to in-store or first purchase situations when judgments are based on visual inspection only. Since oral sensory information is not accessible, heuristics inferences are likely. Some prior studies therefore may have overestimated certain cognitive processes of food decisions, while others may have underestimated the role of implicit processes (oral haptics, habits, Biswas et al. 2014). Researchers should bear in mind that repeated purchases are common in a food context and often taste is known from prior experi-

ence. Holistic study designs with real food products will help to avoid the risk of misleading conclusions. Additionally, Studies 2 to 4 apply a very conservative test of our conceptual framework by examining one condition in a single-product context. As indicated by the strong effects in Study 1b and in line with prior research (e.g., Deng and Kahn 2009), it is plausible to assume that the opposing package color effects are even stronger in a store shelf setting when light-colored packages are placed next to regular or darker packages. Future research should examine such contrasting or assimilating context effects.

Lastly, the implications of this work might extend beyond health issues. Color intensity is used as a salient visual cue to spotlight further seemingly positive product features (e.g., light green packaging to signal sustainability), but which are also known to affect other valued attributes (e.g., product strength, quality) with negative implications for the final decision (Luchs et al. 2010). The opposing effects of this subtle cue should therefore be explored in other contexts too.

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Web Appendix

This Web Appendix provides additional information and gives further details for the analyses reported in the full paper.

Study 2: Moderation of the opposing package color effects

In this section, we provide further details on the data analysis of Study 2. More specifically, we show how the difference between color-induced tastiness and healthiness assessments is passed on to the formation of purchase intentions.

Implications of the gap between tastiness and healthiness for the formation of purchase intentions

We examine the impact of package color on the conflict between taste and health. For the pre-consumption situation (when oral sensory information is not available through tasting), a t-test demonstrates that package color increases the extent to which the evaluations of tastiness surpass health evaluations ($t(177) = 2.644$, $p_{one-tailed} < .01$). While products with regular packaging are perceived more tasty than healthy (tasty-healthy difference score: $\Delta M = .24$), the products with light-colored packaging are perceived relatively healthier than tasty ($\Delta M = -.21$). We observe the same pattern for the post-consumption situation when also sensory information is available through tasting ($t(177) = 1.668$, $p_{one-tailed} < .05$; $\Delta M_{regular} = .15$, $\Delta M_{light} = -.13$).

To assess the implications for consumer decision making, regression analyses with the tasty-healthy difference score as the independent variable shows that the extent to which tastiness evaluations surpass healthiness evaluations fosters the intent to purchase (sensory information not available: $\beta = .24$, $t = 3.309$, $p < .001$; available: $\beta = .26$, $t = 3.625$, $p < .001$). We applied the Preacher-Hayes (2004) bootstrapping procedure (10,000 samples) to analyze the indirect effect of packaging color through the widening gap in the tastiness and healthiness judgments. As the bias-corrected 95% confidence intervals (CI) do not include zero, the indirect effects (IE) are significant in the pre-consumption situation (IE = $-.10$, CI = $-.22$ to $-.01$) and the post-consumption situation (IE = $-.07$, CI = $-.20$ to $-.00$). As will be shown next, the opposing consequences of light-colored packages are dependent on the two suggested boundary conditions.

Moderating effect of health consciousness depending on the consumption timing

Regression analyses were conducted to quantify the impact of package color on product tastiness, healthiness, and purchase intentions in the different consumption situations (i.e., when oral sensory information is missing or available). The analyses further indicate that some of the color-induced influences (direct effects and effects of the mediators) are qualified by the level of health consciousness (Table A.1).

Table A.1. Influences on the evaluations of tastiness, healthiness, and purchase intentions depending on the level of health consciousness.

| <i>Sensory information not available</i> | Tastiness | | | Healthiness | | | Purchase intention | | |
|---|------------------|----------|----------|--------------------|----------|----------|---------------------------|----------|----------|
| | β | <i>t</i> | <i>p</i> | β | <i>t</i> | <i>p</i> | β | <i>t</i> | <i>p</i> |
| Light-colored packaging | -.12 | -1.561 | | .11 | 1.457 | | .01 | .131 | |
| Health consciousness | .15 | 2.058 | * | .00 | -.006 | | .05 | .667 | |
| Light-col. packaging×health consciousness | .09 | 1.216 | | .06 | .745 | | .02 | .234 | |
| Tastiness | | | | | | | .44 | 5.945 | *** |
| Tastiness×health consciousness | | | | | | | -.10 | -1.286 | |
| Healthiness | | | | | | | .04 | .508 | |
| Healthiness×health consciousness | | | | | | | .10 | 1.411 | |

| <i>Sensory information available</i> | Tastiness | | | Healthiness | | | Purchase intention | | |
|---|------------------|----------|----------|--------------------|----------|----------|---------------------------|----------|----------|
| | β | <i>t</i> | <i>p</i> | β | <i>t</i> | <i>p</i> | β | <i>t</i> | <i>p</i> |
| Light-colored packaging | .03 | .463 | | .18 | 2.384 | * | -.04 | -.624 | |
| Health consciousness | -.07 | -.992 | | -.10 | -1.295 | | .10 | 1.691 | + |
| Light-col. packaging×health consciousness | .15 | 2.052 | * | .11 | 1.455 | | -.01 | -.215 | |
| Tastiness | | | | | | | .55 | 8.390 | *** |
| Tastiness×health consciousness | | | | | | | -.13 | -1.855 | + |
| Healthiness | | | | | | | .09 | 1.385 | |
| Healthiness×health consciousness | | | | | | | .19 | 2.750 | ** |

Notes. Regression (OLS), ⁺ $p \leq .1$, * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

Table A.2 shows the results of the mixed-design ANOVA with color intensity as the between-subjects factor and the consumption situation (sensory information available vs. missing) and the tastiness and healthiness evaluations as the within-subjects variables (Model 1a). Model 1b further includes health consciousness as a continuous variable.

Table A.2. Tastiness-healthiness evaluations depending on the package color and the availability of oral sensory information (Model 1a) as well as the level of health consciousness (Model 1b).

| | Model 1a | | Model 1b | |
|--|-----------------|----------|-----------------|----------|
| | <i>F</i> | <i>p</i> | <i>F</i> | <i>p</i> |
| <i>Within-subjects factors</i> | | | | |
| Tastiness-healthiness | .025 | | .022 | |
| Tastiness-healthiness × sensory information | .003 | | .003 | |
| Tastiness-healthiness × color | 6.623 | * | 6.739 | ** |
| Tastiness-healthiness × health consciousness | | | 1.447 | |
| Tastiness-healthiness × color × health consciousness | | | .319 | |
| Sensory information | .011 | | .017 | |
| Sensory information × color | 2.923 | + | 3.231 | + |
| Sensory information × health consciousness | | | 7.457 | ** |
| Sensory information × color × health consciousness | | | .899 | |
| Tastiness-healthiness × sensory information × color | .774 | | .828 | |
| Tastiness-healthiness × sensory information × health consciousness | | | 2.059 | |
| Tastiness-healthiness × sensory information × color × health consciousness | | | .016 | |
| <i>Between-subjects factors</i> | | | | |
| Color | .893 | | .914 | |
| Health consciousness | | | .040 | |
| Color × health consciousness | | | 3.621 | + |

Notes. Mixed-design ANOVA, level of significance: ⁺ $p \leq .1$; * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

Study 3a: Less healthy product variants enhance the negative taste effect (potato chips)

Study 3a used the instruments of Study 2: product tastiness ($M_{\text{round 1}} = 3.92$, $\alpha = .73$; $M_{\text{round 2}} = 4.30$, $\alpha = .75$), healthiness ($M_{\text{round 1}} = 2.33$, $\alpha = .84$; $M_{\text{round 2}} = 2.28$, $\alpha = .90$), purchase intention ($M_{\text{round 1}} = 3.19$, $\alpha = .82$; $M_{\text{round 2}} = 3.51$, $\alpha = .89$), and health consciousness ($M = 4.93$, $\alpha = .80$).

To examine the interplay of the availability of oral sensory information (Model 2a), mixed-design ANOVA with color intensity (between-subjects factor), the availability of the sensory cue (within-subjects factor) and the tastiness/healthiness judgments (within-subjects dependent variable) reveal a strong interaction effect among the three factors ($F(1, 204) = 7.056$, $p < .01$, Table A.3). When including health-consciousness (Model 2b), this effect is further qualified by the level of health-consciousness ($F(1, 202) = 5.126$, $p < .05$).

Table A.3. Tastiness-healthiness evaluations depending on the package color and the availability of sensory information (Model 2a) as well as the level of health consciousness (Model 2b).

| | Model 2a | | Model 2b | |
|--|-----------------|----------|-----------------|----------|
| | <i>F</i> | <i>p</i> | <i>F</i> | <i>p</i> |
| <i>Within-subjects factors</i> | | | | |
| Tastiness-healthiness | .000 | | .003 | |
| Tastiness-healthiness × sensory information | .000 | | .008 | |
| Tastiness-healthiness × color | .273 | | .314 | |
| Tastiness-healthiness × health consciousness | | | .927 | |
| Tastiness-healthiness × color × health consciousness | | | 1.722 | |
| Sensory information | .000 | | .001 | |
| Sensory information × color | 2.480 | | 2.484 | |
| Sensory information × health consciousness | | | .027 | |
| Sensory information × color × health consciousness | | | .889 | |
| Tastiness-healthiness × sensory information × color | 7.056 | ** | 7.182 | ** |
| Tastiness-healthiness × sensory information × health consciousness | | | .014 | |
| Tastiness-healthiness × sensory information × color × health consciousness | | | 5.126 | * |
| <i>Between-subjects factors</i> | | | | |
| Color | .650 | | .769 | |
| Health consciousness | | | 2.737 | + |
| Color × health consciousness | | | 2.787 | + |

Notes. Mixed-design ANOVA, level of significance: ⁺ $p \leq .1$; * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

Table A.4 illustrates the interplay between package color and the availability of oral sensory information by distinguishing between both consumption situations. Separate mixed-design ANOVAs were conducted for the situation when oral sensory information was absent or present.

Table A.4. Tastiness-healthiness evaluations depending on package color and the level of health consciousness (broken down by the availability of sensory information).

| | Sensory information not available (visual perception only) | | | | Sensory information available (tasting possible) | | | |
|--|---|----------|----------|----------|---|----------|----------|----------|
| | <i>F</i> | <i>p</i> | <i>F</i> | <i>p</i> | <i>F</i> | <i>p</i> | <i>F</i> | <i>p</i> |
| <i>Within-subjects factor</i> | | | | | | | | |
| Tastiness-healthiness | .000 | | .000 | | .000 | | .008 | |
| Tastiness-healthiness × color | 2.987 | + | 3.090 | + | .612 | | .573 | |
| Tastiness-healthiness × health consciousness | | | .829 | | | | .627 | |
| Tastiness-healthiness × color × health consciousness | | | .010 | | | | 4.887 | * |
| <i>Between-subjects factor</i> | | | | | | | | |
| Color | .002 | | .000 | | 2.175 | | 2.366 | |
| Health consciousness | | | 1.854 | | | | 2.362 | |
| Color × health consciousness | | | 3.632 | + | | | 1.025 | |

Notes. ANOVA, level of significance: ⁺ $p \leq .1$; * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

As in Study 2, regression analyses were conducted to examine whether the indirect effect is contingent on the level of health consciousness. The analysis quantifies the package color’s influence on the participant’s perception of product tastiness, healthiness, and purchase intentions for both consumption situations, namely, when oral sensory information is missing (i.e., visual perception only) and when sensory information is available (i.e., tasting possible). In line with Study 2, the level of health consciousness moderates some of the color-induced effects (Table A.5).

Table A.5. Influences on the evaluations of tastiness, healthiness, and purchase intentions depending on the level of health consciousness.

| Regression (OLS) | Tastiness | | | Healthiness | | | Purchase intention | | |
|---|------------------|----------|----------|--------------------|----------|----------|---------------------------|----------|----------|
| | β | <i>t</i> | <i>p</i> | β | <i>t</i> | <i>p</i> | β | <i>t</i> | <i>p</i> |
| <i>Sensory information not available</i> | | | | | | | | | |
| Light-colored packaging | -.08 | -1.177 | | .08 | 1.194 | | -.00 | -.059 | |
| Health consciousness | -.03 | -.390 | | -.11 | -1.624 | | .03 | .431 | |
| Light-col. packaging×health consciousness | .09 | 1.336 | | .10 | 1.479 | | .00 | .042 | |
| Tastiness | | | | | | | .61 | 10.729 | *** |
| Tastiness×health consciousness | | | | | | | .01 | .094 | |
| Healthiness | | | | | | | -.06 | -.992 | |
| Healthiness×health consciousness | | | | | | | .10 | 1.686 | + |
| <i>Sensory information available</i> | | | | | | | | | |
| Light-colored packaging | .11 | 1.633 | | .04 | .612 | | -.04 | -.701 | |
| Health consciousness | -.04 | -.582 | | -.12 | -1.672 | + | -.05 | -.754 | |
| Light-col. packaging×health consciousness | -.05 | -.763 | | .16 | 2.258 | * | .06 | 1.011 | |
| Tastiness | | | | | | | .59 | 9.915 | *** |
| Tastiness×health consciousness | | | | | | | -.09 | -1.393 | |
| Healthiness | | | | | | | -.02 | -.302 | |
| Healthiness×health consciousness | | | | | | | .00 | .032 | |

Notes. Regression (OLS), + $p \leq .1$, * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

The magnitude of the indirect effects at the different levels of health consciousness – which were estimated using the Preacher-Hayes (2004) bootstrapping procedure – is presented in Table A.6. As in the full paper, the results show the estimated indirect effects at different percentiles of health consciousness. The lower part of this table also indicates the indirect effects for three equal groups that were derived by splitting the sample according to the level of health consciousness (tertiary split).

Table A.6. Conditional indirect effects of light-colored packages on purchase intention through the mediators at different levels of health consciousness in the different consumption situations.

| Spotlight Analysis | Evaluation when sensory information is | | | | | | | |
|--------------------------------------|--|-----------|-------------|-------------|-----------|-----------|-------------|-------------|
| | not available | | | | available | | | |
| | Mediators | Tastiness | | Healthiness | | Tastiness | | Healthiness |
| | IE | BS | IE | BS | IE | BS | IE | BS |
| Percentiles for health consciousness | | | | | | | | |
| 10 th | -.25 | * | .02 | | .26 | + | .01 | |
| 25 th | -.17 | + | -.00 | | .19 | + | .00 | |
| 50 th | -.10 | | -.01 | | .13 | | -.00 | |
| 75 th | -.02 | | -.00 | | .08 | | -.01 | |
| 90 th | .04 | | .01 | | .05 | | -.01 | |
| Tertiary split | Evaluation when sensory information is | | | | | | | |
| | not available | | | | available | | | |
| Mediators | Tastiness | | Healthiness | | Tastiness | | Healthiness | |
| | IE | BS | IE | BS | IE | BS | IE | BS |
| Health consciousness | | | | | | | | |
| low (n=68, M=3.71) | -.31 | * | .02 | | .17 | | .03 | |
| moderate (n=70, M=5.00) | -.02 | | -.05 | | .14 | | .01 | |
| high (n=68, M=6.09) | -.00 | | .03 | | .08 | | .00 | |

Notes. IE... indirect effect, BS... bootstrapping (10,000 samples), ** 99%-CI \neq 0, * 95%-CI \neq 0, + 90%-CI \neq 0.

Study 3b: More healthy product variants enhance the positive health effect (fruit cereal bar)

Also Study 3b used the instruments of Study 2: product tastiness ($M = 4.75$, $\alpha = .84$), healthiness ($M = 3.78$, $\alpha = .71$), purchase intentions ($M = 3.51$, $\alpha = .76$), and health consciousness ($M = 4.87$, $\alpha = .81$). We followed the same approach that was used in Study 3a to analyze the data. Note that the sensory information factor (visual perception only vs. tasting possible) was specified as a between-subjects factor in this study. Table A.7 shows the interplay between the experimental factors and the tastiness/healthiness evaluations (within-subjects dependent variable), excluding health consciousness as a continuous independent variable (Model 3a) or including this motivational variable (Model 3b).

Table A.7. Tastiness-healthiness evaluations depending on package color and the availability of sensory information (Model 3a) as well as the level of health consciousness (Model 3b).

| | Model 3a | | Model 3b | |
|--|----------|---|----------|----|
| | F | p | F | p |
| <i>Within-subjects factors</i> | | | | |
| Tastiness-healthiness | .001 | | .023 | |
| Tastiness-healthiness × sensory information | .240 | | .323 | |
| Tastiness-healthiness × color | .063 | | .088 | |
| Tastiness-healthiness × health consciousness | | | .660 | |
| Tastiness-healthiness × sensory information × color | 3.302 | + | 3.483 | + |
| Tastiness-healthiness × sensory information × health consciousness | | | .726 | |
| Tastiness-healthiness × color × health consciousness | | | .032 | |
| Tastiness-healthiness × sensory information × color × health consciousness | | | .013 | |
| <i>Between-subjects factors</i> | | | | |
| Sensory information | .624 | | .266 | |
| Color | 3.070 | + | 1.925 | |
| Health consciousness | | | .170 | |
| Sensory information × color | .083 | | .042 | |
| Sensory information × health consciousness | | | .015 | |
| Color × health consciousness | | | .445 | |
| Sensory information × color × health consciousness | | | 6.949 | ** |

Notes. Mixed-design ANOVA, level of significance: ⁺ $p \leq .1$; * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

Table A.8 then shows the regressions for the different consumption situations (i.e., when sensory information is not available or available). Table A.9 presents the conditional indirect effects of package color intensity on purchase intentions via perceived product healthiness and product tastiness in the different consumption situations. We did not conduct the tertiary split because the consumption situation was specified as a between-subjects factor.

Table A.8. Influences on the evaluations of tastiness, healthiness, and purchase intentions depending on the level of health consciousness.

| Regression (OLS) | Tastiness | | | Healthiness | | | Purchase intention | | |
|---|-----------|--------|---|-------------|--------|---|--------------------|--------|-----|
| | β | t | p | β | t | p | β | t | p |
| <i>Sensory information not available</i> | | | | | | | | | |
| Light-colored packaging | .05 | .385 | | .21 | 1.660 | | .05 | .448 | |
| Health consciousness | .03 | .192 | | .02 | .135 | | -.13 | -1.133 | |
| Light-col. packaging × health consciousness | -.27 | -2.115 | * | -.21 | -1.618 | | .11 | .885 | |
| Tastiness | | | | | | | .66 | 6.073 | *** |
| Tastiness × health consciousness | | | | | | | .03 | .235 | |
| Healthiness | | | | | | | .04 | .377 | |
| Healthiness × health consciousness | | | | | | | .04 | .333 | |
| <i>Sensory information available</i> | | | | | | | | | |
| Light-colored packaging | .22 | 1.743 | + | -.03 | -.263 | | .06 | .558 | |
| Health consciousness | -.06 | -.491 | | .13 | 1.024 | | .06 | .613 | |
| Light-col. packaging × health consciousness | .12 | .936 | | .14 | 1.094 | | -.02 | -.190 | |
| Tastiness | | | | | | | .59 | 5.509 | *** |
| Tastiness × health consciousness | | | | | | | .08 | .740 | |
| Healthiness | | | | | | | .09 | .887 | |
| Healthiness × health consciousness | | | | | | | -.15 | -1.316 | |

Notes. Regression (OLS), ⁺ $p \leq .1$, * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

Table A.9. Conditional indirect effects of light-colored packages on purchase intention through the mediators at different levels of health consciousness in the different consumption situations.

| Spotlight Analysis | Evaluation when sensory information is | | | | | | | | |
|--------------------------------------|--|-----------|----|-------------|-----------|-----------|----|-------------|--|
| | not available | | | | available | | | | |
| | Mediators | Tastiness | | Healthiness | | Tastiness | | Healthiness | |
| | IE | BS | IE | BS | IE | BS | IE | BS | |
| Percentiles for health consciousness | | | | | | | | | |
| 10 th | .57 | + | | -.02 | .05 | | | -.13 | |
| 25 th | .24 | | | .01 | .16 | | | -.03 | |
| 50 th | -.01 | | | .02 | .27 | * | | .00 | |
| 75 th | -.19 | | | .01 | .32 | * | | .00 | |
| 90 th | -.37 | | | -.00 | .40 | * | | -.01 | |

Notes. IE... indirect effect, BS... bootstrapping (10,000 samples), ** 99%-CI \neq 0, * 95%-CI \neq 0, + 90%-CI \neq 0.

Study 4: Dependency on product healthiness (intra-product comparison)

The last experiment in our series of studies manipulates product healthiness for the very same product. Next, we provide further information on the measurement and the rationale that guided the manipulation of the stimulus materials. We also present the full ANOVA models.

Measurement of the relevant variables

Owing to the fact that Study 4 examines a product from the product category beverages, we slightly adapted and extended the measurements. The questionnaire asked the subjects to assess product healthiness using a four-item seven-point semantic differential scale ($M = 5.07$, $\alpha = .77$; “healthy/unhealthy”, “rich/poor in vitamins”, “calorie-rich/poor”, “energy-dense/poor”) and tastiness with a four-item seven-point semantic differential scale ($M = 5.16$, $\alpha = .93$; “tasty/ less tasty”, “enjoyable/not enjoyable”, “appetizing/unappetizing”, “fruity/not fruity”). The participants also indicated their purchase intentions using a three-item seven-point Likert scale ($M = 4.44$, $\alpha = .91$; e.g., “I will buy this product.”, “Next time I buy orange juice, I will buy this product”, “I would prefer this product over other products.”). We also measured several control variables (thirst, body mass index, age, gender, interestingness, liking of orange juice). Even though, we do not analyze this in the full paper, we measured the participant’s level of health consciousness with the help of the instrument that was used in the previous studies ($M = 4.99$, $\alpha = .81$).

Rationale for the manipulation of the treatment

As in Study 2, the choice of the product and the manipulation of the stimulus materials build on exploratory interviews. We used orange juice as the focal product, because most

consumers are familiar with this type of product and we did not expect many consumers to dislike orange juice. To manipulate the treatment conditions, we systematically varied the labeling. Great care was taken to ensure a subtle manipulation that allows keeping most elements of the label constant as well as the product itself. Since the interviews implied that pure squeezed fruit juice (i.e., not from concentrate) is associated with health benefits, the label indicated that the product was either pure squeezed juice or juice from concentrate. The label's color was either green (which the respondents associated with healthy nutrition) or blue (which was perceived neutral). Again, color intensity was manipulated by increasing (or decreasing) color lightness to keep the type of color constant (green hue value = 89, saturation = 255; blue: hue = 157, saturation = 255). To derive a finer graduation than in Study 1 and to check for non-linear effects, we applied three levels of color intensity. Lightness values were selected in such a way that the visual appearance is similar for green (lightness values = 102, 69 and 25) and blue tones (182, 98 and 50).

Although we used a fictitious brand ("Nadera"), the label's design was inspired by that of real brands. The label contains elements that are commonly used (e.g., pictures of oranges, brand logo) and it shows all mandatory declarations (e.g., nutrition facts, best-before date). The manipulated labels were affixed to glass bottles with a brass-colored cap. All bottles contained regular orange juice. A qualitative pretest (ten subjects) checked for ecological validity of the stimulus material. The labels and the manipulation were perceived as realistic.

Results

As in the previous studies, mixed-design ANOVA was conducted with the experimental factors and the evaluations of product tastiness and healthiness as the repeated dependent variable (Model 4a). The results clearly show that each experimental factor moderates the tastiness-healthiness evaluations (color intensity: $F(2, 228) = 4.463, p < .05$; type of color: $F(1, 228) = 4.766, p < .05$; type of product: $F(1, 228) = 3.242, p = .07$). Even more importantly, there is a marginally significant interaction effect among the three experimental factors ($F(2, 228) = 2.698, p = .07$). In Model 4b, we additionally included health consciousness as a continuous variable. The results remain relatively stable and health consciousness further moderates some of the two-way and three-way interactions (Table A.10).

Table A.10. Tastiness-healthiness evaluations depending on package color lightness, the type of color, and the type of product (Model 4a) as well as the level of health consciousness (Model 4b).

| | Model 4a | | Model 4b | |
|--|-----------------|----------|-----------------|----------|
| | <i>F</i> | <i>p</i> | <i>F</i> | <i>p</i> |
| <i>Within-subjects factors</i> | | | | |
| Tastiness-healthiness | .000 | | .090 | |
| Tastiness-healthiness × color intensity | 4.463 | * | 4.077 | * |
| Tastiness-healthiness × type of color | 4.766 | * | 2.691 | |
| Tastiness-healthiness × type of product | 3.242 | + | 3.098 | + |
| Tastiness-healthiness × health consciousness | | | 1.786 | |
| Tastiness-healthiness × color intensity × type of color | .542 | | .180 | |
| Tastiness-healthiness × color intensity × type of product | .620 | | 1.325 | |
| Tastiness-healthiness × color intensity × health consciousness | | | .819 | |
| Tastiness-healthiness × type of color × type of product | 1.280 | | 1.402 | |
| Tastiness-healthiness × type of color × health consciousness | | | .070 | |
| Tastiness-healthiness × type of product × health consciousness | | | 1.007 | |
| Tastiness-healthiness × color intensity × type of color × type of product | 2.698 | + | 2.762 | + |
| Tastiness-healthiness × color intensity × type of color × health consciousness | | | 2.716 | + |
| Tastiness-healthiness × color intensity × type of product × health consciousness | | | .527 | |
| Tastiness-healthiness × type of color × type of product × health consciousness | | | 1.174 | |
| Tastiness-healthiness × color intensity × type of color × type of product × health consciousness | | | .328 | |
| <i>Between-subjects factors</i> | | | | |
| Color intensity | 11.327 | *** | 8.942 | *** |
| Type of color | 9.928 | ** | 9.922 | ** |
| Type of product | 20.064 | *** | 13.501 | *** |
| Health consciousness | | | .000 | |
| Color intensity × type of color | 1.832 | | 2.614 | + |
| Color intensity × type of product | 2.542 | + | 3.780 | * |
| Color intensity × health consciousness | | | .820 | |
| Type of color × type of product | .019 | | .520 | |
| Type of color × health consciousness | | | 3.666 | + |
| Type of product × health consciousness | | | .333 | |
| Color intensity × type of color × type of product | 1.320 | | 1.792 | |
| Color intensity × type of color × health consciousness | | | 2.936 | + |
| Color intensity × type of product × health consciousness | | | 1.531 | |
| Type of color × type of product × health consciousness | | | 1.974 | |
| Color intensity × type of color × type of product × health consciousness | | | 1.038 | |

Notes. Mixed-design ANOVA, level of significance: + $p \leq .1$; * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$.

E.2 – Have an eye on the buckled cucumber: An eye tracking study on visually suboptimal foods

Abstract

Waste is an ever growing problem in the food supply chain, starting in the production up to the consumers' households. A precondition for a consumer to purchase a product is to recognize it as an option in the first place. Therefore, in the present study, we investigated eye movement behavior on impeccable and visually suboptimal food items in a purchase or discard decision task. Additionally, in some trials price badges of the suboptimal food items were designed specifically in order to attract attention. Design changes included messages regarding price and taste, respectively, either presented in red or green. The results show that the design changes indeed attracted attention towards suboptimal food items in terms of time to first fixation, and also prolonged total fixation duration. However, only color yielded differences between the design variations, with red resulting in longer total fixation durations. Additionally, we inspected choice behavior towards visually suboptimal food items. As can be expected, purchase decisions declined for the suboptimal as compared to the impeccable items. However, when presented with differently designed price badges, a positive trend to purchase the suboptimal items was obtained. Our results show that price badge designs impact attention, cognitive processing, and finally also purchase decisions. Therefore, supplying visually suboptimal food in stores should be embedded into efforts to attract attention towards these products, as selling visually suboptimal food might positively impact waste balance in the food domain.

Keywords

Eye tracking, Visually Suboptimal Food, Sustainability, Consumers, Visual Attention

1 Introduction

The food supply chain is a waste chain at the same time – from the very beginning of the production up to the consumer at the other end. Current estimates amount food losses to about one third of the world's overall food (FAO, 2014). Responsibilities for food waste are manifold – production and transport, retailing, and finally, the consumer (for a current overview covering the whole production chain, see Raak, Symmank, Zahn, Aschemann-Witzel, & Rohm, 2016). The rejection of products with imperfect physical appearance (e.g. buckled cucumber, crushed packages, etc.; Gustavsson, Cederberg, Sonesson, von Otterdijk, & Meybeck, 2011) plays a major role in food waste. To let consumers decide whether visually suboptimal food could be a purchase option, these suboptimal items have to reach the supermarket shelves. Ecological and sustainability considerations might increase the pressure to develop concepts of how to present and sell suboptimal food stimuli in supermarkets (Aschemann-Witzel, 2016).

Shakespeare, in *Love's labour lost*, stated "Beauty is bought by judgment of the eye." This is even more true when considering real products offered in a supermarket. The first contact of a consumer with a potential purchase is usually visual and, vice versa, to become a potential choice, a product has to be noted, i.e. visually attended to (Orquin & Loose, 2013). Food appearance, in terms of the product itself or the product's packaging, is relevant for the judgment of product quality, and therefore influences whether a consumer makes a purchase or rejection decision (Eldesouky, Pulido, & Mesias, 2015).

For fresh products (vegetables, fruits) often sold without extensive packaging, however, quality assessment almost solely relies the product itself; therefore, deviations in shape, color or size may imply lower quality (Cardello, 1994), leading to rejection in the food chain long before reaching the supermarket shelves. The price is always present in shopping situations either directly on the package or on the supermarket shelves – and therefore, price badge design is an important factor in retailing. Especially color proved to impact consumer decisions in various ways (Elliot & Maier, 2014; Paul & Okan, 2011) Puccinelli, Chandrashekar, Grewal, and Suri (2013) investigated how color (red vs. black) of price information influences perceived savings. They showed an advantage for red over black and that this effect is gender-specific (only present for male participants). However, as price information on the advertisements was embedded in additional text elements printed in black, it remains unclear whether the effect could be attributed specifically to the color, or rather is – on a more abstract level – a result of color singletons (e.g. Horstmann, 2002), automatically

attracting attention towards deviating color information (Hochstein & Ahissar, 2002; Treisman & Gelade, 1980).

Consumers' interest into products can be investigated in many different ways, including surveys, questionnaires and direct observations, or by means of recording physiological parameters. Among the latter ones, eye tracking is the most promising method to gather information of what attracts consumer attention. Measures of gaze behavior are influenced in different stages of evaluation processes. Low level, automatic attentional orientation (Treisman & Gelade, 1980) results in shorter times until the first fixation in a given area of interest (Orquin & Loose, 2013; Shimojo, Simion, Shimojo, & Scheier, 2003). Cognitive processes are reflected in fixation durations, with longer durations associated with higher complexity, such as in reading (Rayner, 1998), mental operations (Unema & Rötting, 1990), or usability (Goldberg & Kotval, 1999). In general, longer fixations reflect deeper processing of the extracted visual information (Velichkovsky, 2002).

While questionnaire and survey results are often biased towards social desirability, the orientation of the eyes provides a most direct measure of visual attention. However, studies attempting to use this method in real shopping situations (e.g. Chandon, Hutchinson, Bradlow, & Young, 2009; Clement, 2007) revealed problems with data quality, and an immense effort for data analysis. Collecting data on choice behavior in a laboratory setting allows for a better experimental control but reduces external validity. More specifically, settings are often restricted to dichotomous decisions by presenting only two stimuli in parallel (e.g. Shimojo et al., 2003; Simion & Shimojo, 2006; van der Laan, Hooge, de Ridder, Viergever, & Smeets, 2015). Such experimental designs have the advantage that each trial results in one chosen and one rejected stimulus but the ecological validity of such dichotomous laboratory choice situations can be questioned: In a real shopping situation, a purchase decision usually comprises more than two items. Therefore, including a larger number of stimuli into a presentation matrix seems logical when investigating consumer decisions.

In addition to the number of stimuli, their features of appearance are of relevance. Basic research distinguishes bottom-up and top-down factors of attention, with bottom-up factors including all aspects of visual appearance or salience such as color, contrast, or luminance (Itti & Koch, 2000). Bialkova and van Trijp (2010) demonstrated the influence of bottom-up features on the search behavior. Top-down aspects also play an important role in capturing attention (Yarbus, 1967): When inspecting a painting repeatedly, it was shown that different instructions guide visual attention, resulting in distinguishable fixation patterns on the scene. In marketing research, top-down attention is increasingly relevant (Milosavljevic &

Cerf, 2008). Consumer intentions, goals, or pre-existing attitudes may bias purchase decisions, thereby possibly overriding first impressions guided by bottom-up processes.

Bialkova and van Trijp (2011) proposed a methodology for the assessment of visual attention deployment in the context of food evaluation, combining eye tracking measures, response times, and choice behavior on two simultaneously presented items. The present study, in principle, follows this procedure but, to reflect the variety and complexity of food products in a real shopping situation, subjects were asked to make choices from matrices with eight food items. The matrices contained what we denote relevant items, and their appearance was systematically varied over the condition: it could be an impeccable product, a visually suboptimal version of the same product, or the suboptimal version supplemented with a specifically designed badge.

With this set-up, we aimed to test four hypotheses. (1) Items with specifically designed price badges attract attention, reflected by shorter times to first fixation. This hypothesis is motivated by findings regarding pop out (Hochstein & Ahissar, 2002; Treisman & Gelade, 1980), but also by the assumption that time to first fixation plays an important role in decision formation (Shimojo et al., 2003). (2) Items with specifically designed price badges are processed more deeply (i.e. with greater effort), reflected by longer total fixation durations (e.g. Just & Carpenter, 1976; Velichkovsky, 2002). (3) Differently designed price badges attract attention not only to the item containing the information, but also shift attention towards the price region. The color of price information impacts cognitive processing of this information (Puccinelli et al., 2013), and attracts attention on a micro-level. (4) Differently designed price badges increase the probability of purchase of visually suboptimal products, but do not change the rate of discard decisions.

2 Methods

2.1 Participants

30 subjects (N = 21 female, mean age 40 years, SD = 14.6 years) participated in the study. Participants were recruited with the help of a marketing research agency. Inclusion criteria were full age, working or retired, involved in food shopping and in the preparation of meals. All participants had normal or corrected to normal vision. The study was conducted in line with the declaration of Helsinki. Subjects were rewarded € 20 for participation.

2.2 Materials

In the experiment, subjects were presented matrices comprising food items, arranged in a 3x3 grid, with the central position left empty to avoid central gazing bias (Atalay, Bodur, & Rasolofoarison, 2012; Tatler, 2007). The raw material for constructing the matrices consisted, on the one hand, of eight food items (cucumber, banana, piece of butter, juice carton, carrot, apple, milk carton, pile of cookies). Each of these baseline items was composed of an image of a typical supermarket product in the center, with a price badge in the lower right corner. Additional eight items were photographed as visually suboptimal versions, i.e. a buckled cucumber, a pile of partially crumbled cookies, an apple with a small brown spot etc. These suboptimal items were also presented with differently designed price badges. Two aspects of the price badges were manipulated: color and information. Color could be either green or red, and the information added was either "Great in taste" or "Small in price", resulting in four combinations. For the information "Small in price", the depicted price on the price badge had a 50 percent discount as compared to the other items (see Figure 1 for examples).

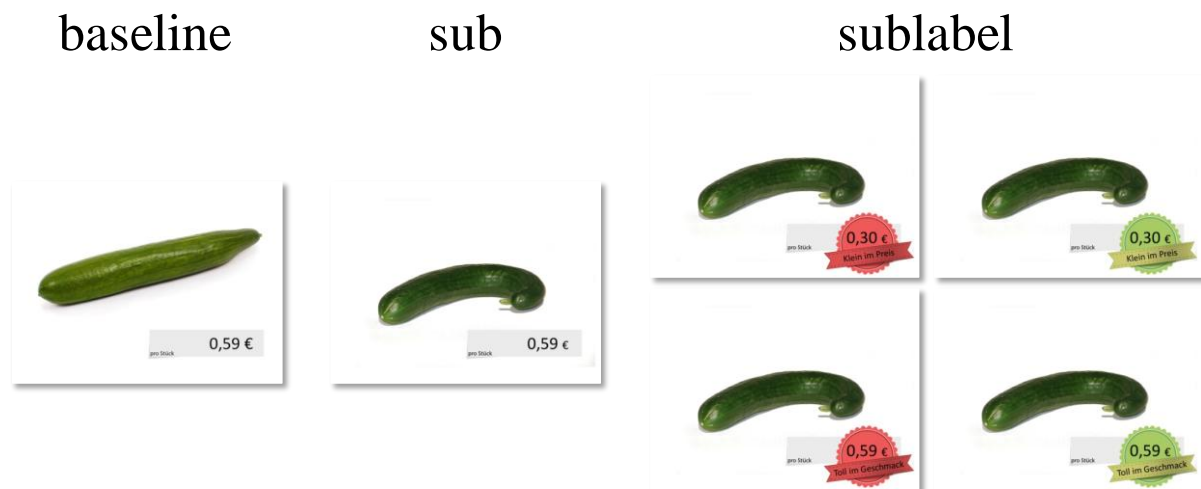


Fig. 1. Examples of baseline version (left), visually suboptimal version (2nd from left, sub), and all four combinations of color and information manipulations (sublabel). Note the actual 50% discount for price information.

Summarized, there were 48 relevant item versions: eight baseline items of optimal visual appearance, eight visually suboptimal items of the same products, and 32 visually suboptimal items with added labels (2 colors x 2 information x 8 items). These 48 relevant items were accompanied by, on the other hand, 32 filler items. Their appearance was the same as the relevant baseline items, but displayed other food products. Of the resulting total of 80 food items, 25 were based on images from the food-pics database (Blechert, Meule, Busch, & Ohla, 2014); the rest was photographed in house in the same style.

136 matrices were constructed. Within a particular matrix, the same item was not shown twice. The three different matrix versions served as conditions for the analyses:

- 40 matrices constituted the baseline. These matrices contained relevant items of optimal visual appearance and filler items. Each item was displayed 8 times. No position restrictions were considered for this condition (Figure 2, left).
- The condition with visually suboptimal items comprised 32 matrices (henceforth sub). Using an incomplete Latin square, the 8 relevant visually suboptimal items were spread over the positions. Filler items were added randomly (Figure 2, midst).
- The third condition contained the 32 relevant labeled items (henceforth sublabel). Again a Latin square was used to allocate the relevant items to the positions, and filler items served to randomly complete the remaining positions in the matrices. 64 matrices were constructed, so that each item by color by information version appeared twice (Figure 2, right).

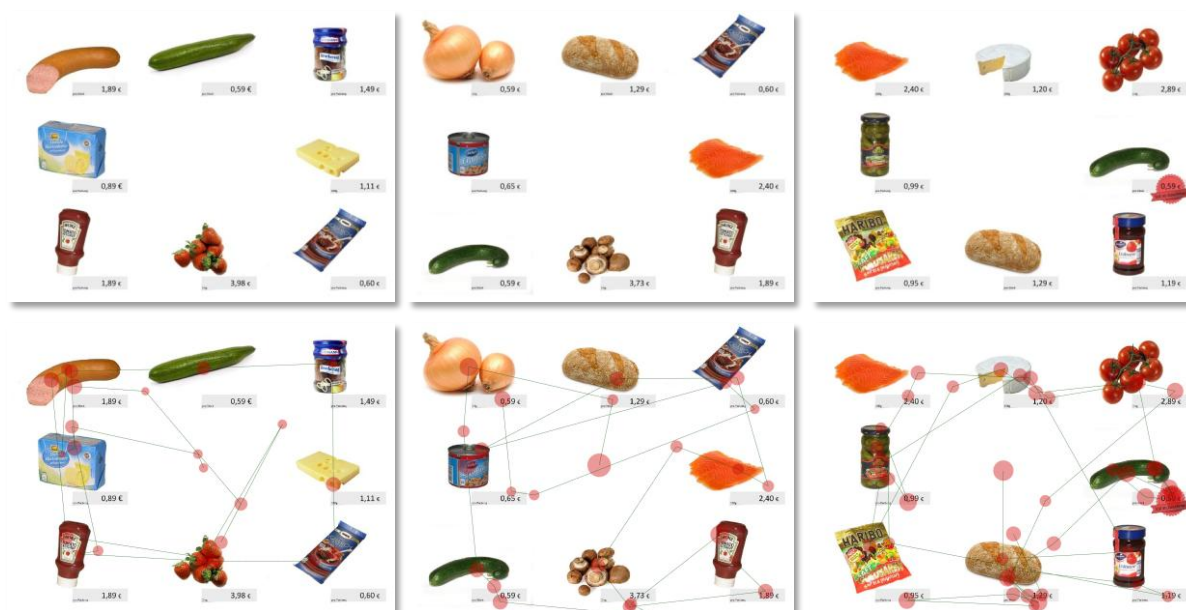


Fig. 2. Examples of matrices for the baseline, sub, and sublabel condition, respectively (upper row). In the lower row, overlaid scan paths on the same matrices, with circles denoting fixations, and lines denoting saccades. Circle sizes vary with fixation duration, with higher durations resulting in larger circles.

2.3 Apparatus

Participants were seated individually in a dimly lit room. Matrices were displayed full screen on a 19-inch CRT monitor (Iiyama Vision Master 451); viewed from a distance of 60 cm, the resulting viewing angle was approximately 25° vertically and 33° horizontally. Screen resolution was 1024 by 768 pixels with a refresh rate of 100 Hz. Eye movements were recorded monocularly with a sample rate of 1000 Hz using the SR Research Ltd. EyeLink

1000 eye-tracking system (SR Research, Ontario, Canada), with a spatial resolution below 0.01° and a spatial accuracy of better than 0.5° . Head movements were restrained by a chin and forehead rest. Standard online saccade detection algorithm supplied by SR Research was used, resulting in saccade identification by deflections of eye position in excess of 0.1° , with a minimum velocity of 30° s^{-1} and a minimum acceleration of $8000^\circ \text{ s}^{-2}$, maintained for at least 4 ms.

2.4 Procedure

The study comprised three parts; order was kept constant across participants. First of all, subjects filled in a questionnaire on demographic details, diet preferences, allergies, and general food related life style. Second, the eye tracking experiment was conducted, and finally, subjects answered a survey collecting data on their general attitudes towards sustainable life style, food waste behavior at home, and preferences on food product qualities; survey data will not be discussed in this paper.

For the eye tracking experiment, subjects were asked to find a comfortable position, allowing them to keep this position for approximately 40 min. Next, they read the instruction on the screen. The task for the subjects was as follows: After a drift correction in the screen center, a matrix containing eight food stimuli was presented. Subjects were to thoroughly inspect the matrix to answer one of two possible questions presented after the matrix: "Which of the objects would you like to keep in your shopping cart?", or "Which of the objects would you discard from your shopping cart?". The matrix inspection task was self-paced, i.e. when subjects felt ready to answer the question, they could terminate the matrix presentation with a mouse click. After that, the matrix disappeared, leaving a pattern of the matrix positions only. Then subjects made a mouse click in one of the eight positions to index the selected stimuli. The next trial started again with a drift correction.

After instruction, subjects completed three sample trials, with the opportunity to ask questions. Then, the eye tracker was calibrated employing a 9-point calibration. The order of the matrices in the following experiment was randomized for each participant. After half the trials, subjects were allowed to take a rest of three minutes.

2.5 Data Analysis

All analyses were conducted using SPSS 22. We followed a multi-step procedure. Statistical tests comprised analyses of variance (ANOVAs). When the sphericity assumption

was violated, Greenhouse-Geisser corrections were used to compensate; in these cases, epsilon correction is reported additionally.

For eye movement data, dependent measures were analyzed based on Areas of Interest (AOI), with each food item constituting a single, non-overlapping AOI. Each of the eight AOIs had dimensions of 341 by 256 pixels, respectively. Time to first fixation (time until the first fixation within the AOI was detected) and total fixation durations (sum of all fixation durations within a given AOI) were analyzed. Each AOI can be further divided into a price region and a product region, respectively. The price region comprised the lower right part of the picture, with 122 by 84 pixels, i.e. 12% of the whole item area. Each AOI attention distribution was measured as the percentage of fixations falling within the price region per item. Additionally, item coverage as global measure was obtained, counting how many of the eight presented food items were fixated within a single trial.

In the first step, the three conditions baseline, sub, and sublabel were compared, separating relevant and filler items. This resulted in a 3 (condition) by 2 (item) repeated measure ANOVA. As the number of filler items in the sub and sublabel conditions are always seven, while there is only one relevant item, for each subject and each trial (also those from the baseline condition) one filler item was selected randomly, serving as input for the ANOVAs¹⁰. In the second step, differences within the sublabel condition were explored. Here, only the relevant items were considered, resulting in two (information: price vs. taste) by two (color: green vs. red) repeated measures ANOVAs. Choice behavior was measured as percentage of relevant items chosen per condition, and again also within sublabel condition.

3 Results

3.1 Task difficulty and accurateness

To test for possible differences between the conditions in terms of task difficulty and accurateness, viewing times and item coverage were analyzed. The latter measure denotes the number of items looked at in a single trial by a subject. A repeated measures ANOVA with condition (baseline, sub, sublabel) as independent variable revealed neither significant differences for reaction time, $F(2, 58) = 1.03$, $p = .37$, $\epsilon = .83$, $\eta^2 = .03$, nor for item coverage, $F < 1$. Mean viewing time varied between 6.4 s (sub) and 6.6 s (baseline) per matrix, with sublabel in between (6.5 s), while item coverage varied between 6.6 (baseline and sub) and 6.7 (sublabel) items per trial.

¹⁰ The same analyzes recruiting the means of the seven filler items instead of one randomly selected item revealed similar means and variations and therefore also the same pattern of statistical results.

Within the sublabel condition, 2 (color: red vs. green) by 2 (information: price vs. taste) repeated measures ANOVAs did not yield significant differences for viewing times, all F 's < 1.186 , with the mean reaction time around 6.5 s. Item coverage within trials reached significance for information, $F(1, 29) = 7.52$, $p = .01$, $\eta^2 = .06$. In trials with the price badge carrying taste information, more items were covered (mean = 6.7) than when carrying price information (mean = 6.5). Neither for color, $F < 1$, nor for the interaction, $F(1, 29) = 1.40$, $p = .25$, $\eta^2 = .01$, further significant differences were observed.

3.2 Eye movement parameters between conditions

In a first step, all dependent measures (time to first fixation, total fixation duration, and attention distribution) were analyzed separately by repeated measures ANOVAs with condition (baseline, sub, sublabel) and item (filler, relevant) as independent variables. All results of the analyses are presented in Table 1.

Table 1. Eye movement measures for relevant and filler items per condition. Values represent mean values, and standard deviations in parentheses.

| Eye movement parameters | baseline | | sub | | sublabel | |
|------------------------------|------------|------------|------------|------------|------------|------------|
| | filler | relevant | filler | relevant | filler | relevant |
| Time to first fixation (ms) | 1781 (604) | 1887 (602) | 1877 (613) | 1738 (514) | 2039 (602) | 1591 (487) |
| Total fixation duration (ms) | 599 (257) | 693 (332) | 559 (241) | 759 (406) | 540 (222) | 998 (563) |
| Attention distribution (%) | 27 (11) | 30 (13) | 33 (15) | 39 (13) | 33 (12) | 53 (12) |
| Items covered | 6.7 (1.4) | | 6.7 (1.3) | | 6.6 (1.2) | |

As can be seen in Table 2, all dependent measures yielded significant interactions of item and condition. In accordance with our hypotheses, eye movements falling on relevant items differ from those on the filler item depending on condition.

Table 2. Statistical summaries of the condition (baseline, sub, sublabel) by item (filler, relevant) repeated measures ANOVAs on time to first fixation, total fixation duration, and attention distribution.

| Eye movement parameters | <i>df</i> (<i>df</i> Error) | <i>F</i> | η^2 | ϵ | <i>p</i> |
|--------------------------------|------------------------------|----------|----------|------------|----------|
| Time to first Fixation | | | | | |
| Main effect condition | 2 (58) | <1 | | | |
| Main effect item | 1 (29) | 8.11 | .07 | 1 | .008 |
| Interaction | 2 (58) | 15.57 | .14 | 1 | <.001 |
| Total fixation duration | | | | | |
| Main effect condition | 2 (58) | 17.11 | .06 | .84 | <.001 |
| Main effect item | 1 (29) | 31.03 | .29 | 1 | <.001 |
| Interaction | 2 (58) | 18.98 | .11 | .79 | <.001 |
| Attention distribution | | | | | |
| Main effect condition | 2 (58) | 90.33 | .32 | 1 | <.001 |
| Main effect item | 1 (29) | 79.65 | .22 | 1 | <.001 |
| Interaction | 2 (58) | 32.27 | .15 | 1 | <.001 |

Therefore, in a second step, *differences* between relevant and filler items were calculated. With condition (baseline, sub, sublabel) as independent variable, repeated measures ANOVAs were conducted for each of the three dependent difference measures, i.e. time to first fixation, total fixation duration, attention distribution. Results are presented in Table 3.

Table 3. Statistical summaries of the ANOVAs on the difference measures between conditions.

| Eye movement parameters | <i>df</i> (<i>df</i> Error) | <i>F</i> | η^2 | ϵ | <i>p</i> |
|--|------------------------------|----------|----------|------------|----------|
| Time to first fixation relevant-filler | | | | | |
| Main effect condition | 2 (58) | 15.57 | .35 | 1 | <.001 |
| Total fixation duration relevant-filler | | | | | |
| Main effect condition | 2 (58) | 18.98 | .40 | .79 | <.001 |
| Attention distribution relevant-filler | | | | | |
| Main effect condition | 2 (58) | 32.37 | .53 | 1 | <.001 |

Simple post-hoc tests of differences with Bonferroni correction for multiple comparisons revealed for all dependent measures the following pattern: No difference between baseline and sub, but significant differences against sublabel, respectively. Additionally, the difference measures in each condition were statistically tested with simple t-tests against zero. The results are presented in Figure 3.

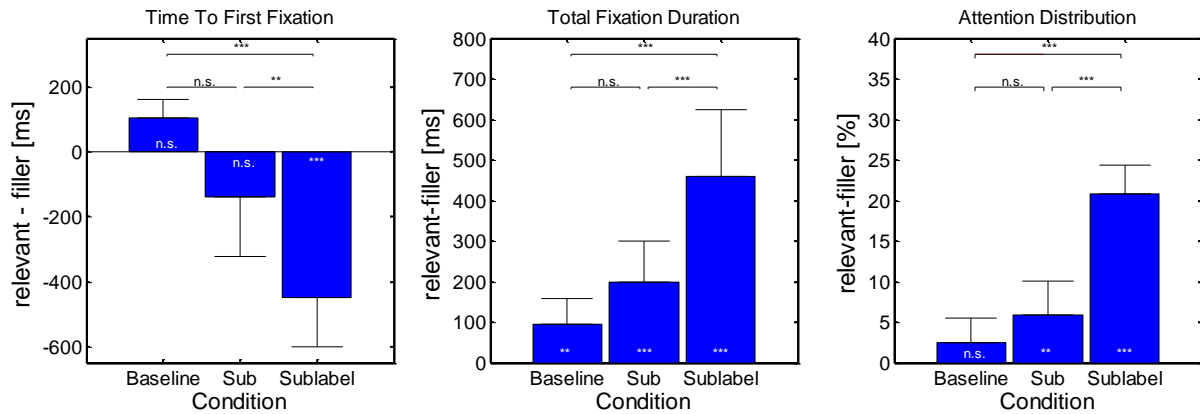


Fig. 3. Differences between relevant and filler item per condition. Statistical statements in upper part of the figures denote differences between conditions. Statistical statements inside bars denote deviation from zero. Error bars represent 95% confidence intervals.

Note: n.s. non-significant, * $p < .05$, ** $p < .01$, *** $p < .001$.

3.3 Eye movement parameters within sublabel condition

Table 4 presents the results obtained for the 2 (information: price vs. taste) by 2 (color: red vs. green) repeated measures ANOVAs within the sublabel condition. No significant differences were obtained for time to first fixation, all F 's < 1.2 . Total fixation duration differed between color, $F(1, 29) = 5.24$, $p = .03$, $\eta^2 = .04$, but not between information, $F < 1$. Also the interaction of both factors did not reach significance. For attention distribution, a significant main effect was obtained for information, $F(1,29) = 5.95$, $p = .02$, $\eta^2 = .05$, but not for color, $F(1, 29) = 1.76$, $p = .195$. The interaction of both reached significance, $F(1, 29) = 9.45$, $p = .005$, $\eta^2 = .07$.

Table 4. Eye movement measures for relevant items, comparing the two by two manipulations within the sublabel condition. Values represent mean values and standard deviations in parentheses.

| Eye movement parameters | Color | | | |
|------------------------------|----------------------|----------------------|----------------------|----------------------|
| | Green | | Red | |
| | Information Price | Information Taste | Information Price | Information Taste |
| Time to first fixation (ms) | 1610 (558) | 1648 (581) | 1534 (620) | 1583 (466) |
| Total fixation duration (ms) | 967 (610) | 944 (567) | 1056 (567) | 1024 (676) |
| Attention distribution (%) | 50 (14) | 55 (14) | 55 (14) | 54 (13) |
| Items covered | 6.5 (1.3) | 6.6 (1.3) | 6.5 (1.3) | 6.7 (1.1) |

3.4 Choice behavior

In half of the trials after matrix inspection, subjects were asked for the stimuli they would discard from a shopping basket, while in the other half, the question asked for one product to be kept in the basket. Though the nature of question should not have any influence

on gazing behavior concerning the relevant stimuli (Vu, Tu, & Duerrschmid, 2016), it does play a role when considering choice behavior. Therefore, the type of question (discard *vs.* keep) was added as independent variable.

First of all, we were interested in the proportion of relevant stimuli being chosen. For each condition by question combination the percentage of chosen relevant stimuli was calculated and then administered to a 3 (condition: baseline, sub, sublabel) x 2 (question: purchase *vs.* discard) repeated measures ANOVA. There was a significant main effect of condition, $F(2, 58) = 7.02, p = .002, \eta^2 = .08$, but not of question, $F < 1$. However, the interaction of both reached significance, $F(2, 58) = 13.86, p < .001, \varepsilon = .796, \eta^2 = .10$. For the discard question, there was no significant difference between the conditions, $F < 1$. However, for the purchase question, condition differed significantly, $F(2, 58) = 22.60, p < .001, \eta^2 = .44$, with 34% in the baseline, 12% in the sub, and 18% in the sublabel condition. However, Bonferroni corrected post-hoc test reveals the difference of interest between sub and sublabel to be non-significant, $p = .182$ (Figure 4).

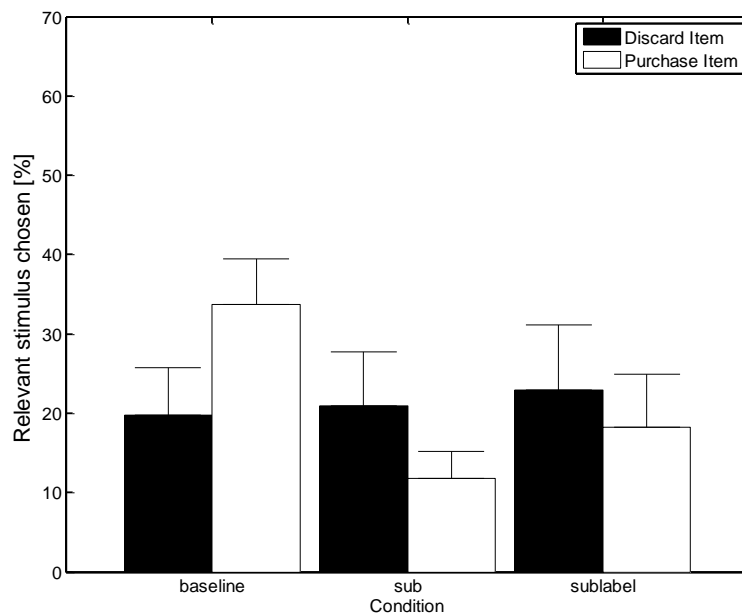


Fig. 4. Proportion of relevant stimuli chosen in baseline, sub, and sublabel condition, respectively; Error bars represent 95% confidence intervals.

In a second step, we analyzed possible effects of information and color within the sublabel condition. A 2 (question: keep *vs.* discard) x 2 (color: red *vs.* green) by 2 (information: price *vs.* taste) repeated measures ANOVA was conducted on the proportion of relevant stimuli selected. There was a significant main effect for information, $F(1, 29) = 5.99, p = .021, \eta^2 = .02$, with higher selection rates for price ($M = 23%$) than for taste ($M = 18%$).

No further main effects were obtained, all F 's < 4.04 , p 's $> .054$. However, the 3-way interaction of question, color, and information had a substantial influence, $F(1, 29) = 9.09$, $p = .005$, $\eta^2 = .02$.

To further investigate the influence of the question on the results, two additional repeated measures ANOVAs with color (red vs. green) and information (price vs. taste) as independent variables were conducted separately. For the discard question, neither color, $F(1, 29) = 2.78$, $p = .106$, nor information, $F < 1$, reached significance level, but the interaction of both did, $F(1, 29) = 15.54$, $p < .001$, $\eta^2 = .12$. As can be seen in Figure 5 (left), products with red color and price information ($M = 28\%$) were most often chosen, followed by green/taste combination ($M = 26\%$), whereas red/taste ($M = 21\%$) and green/price ($M = 18\%$) received lowest choice probabilities. For the purchase question, the results are more straightforward: no significant influence of color, $F < 1$, but clearly for information, $F(1, 29) = 6.78$, $p = .014$, $\eta^2 = .12$, and with no interaction between the factors, $F < 1$. With prices reduced ($M = 24\%$), purchase decision was substantially higher than with the taste information ($M = 13\%$) provided (Fig. 5, right).

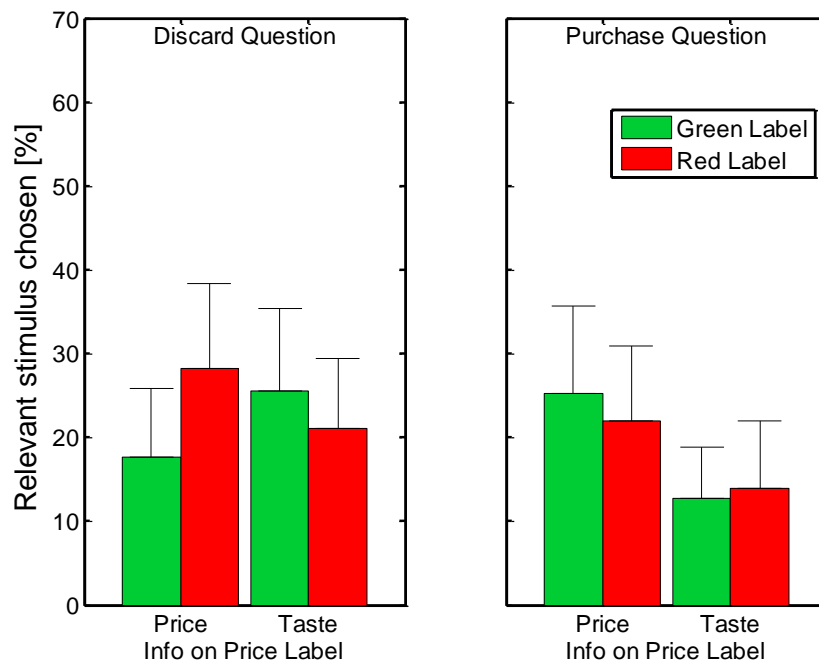


Fig. 5. Interaction of color and information in trials with discard question (left), and with purchase question (right); error bars represent 95% confidence intervals.

4 Discussion

The results of the present study showed that price badge design has an impact on eye movement behavior. Food items with deviating price badges were looked at faster, inspected longer, and within the food item, more fixations towards the deviating price badge were obtained. The analyses of the color and information variations of the price badges, however, revealed a more differentiating pattern: There was no influence on time to first fixation, but longer inspection times on red items. Both attention distribution and item coverage was higher in trials containing food items that carried the taste information. The choice behavior varied with conditions and task: Purchase decisions for relevant items dropped in the sub condition, while the percentage of choice remained stable over the conditions for the discard question.

Analyses of reaction and item coverage on a global level between conditions did not differ, showing that the manipulations did not increase task difficulties, nor did they impact the subjects' accuracy in global scanning behavior. However, rather surprisingly, we found a significant difference of item coverage within the sublabel condition, i.e., more items were covered when the price badge emphasized taste as compared to when it carried price information. An explanation for this finding could be based on consumer anticipation regarding suboptimal food: Price reduction is expectable, whereas an information on taste quality might lead to further scanning of the offered items.

The analyses on time to first fixation supports our first hypothesis, showing that colored price badges with additional information attract attention. Presumably, this can be explained with an effect known from basic psychological research, i.e. pop out (Hochstein & Ahissar, 2002; Treisman & Gelade, 1980). Objects that differ in one salient feature, in this context namely color and form, tend to be found and attended to without effort, possibly in a rather automatic way. This interpretation is supported by the fact that no further differentiation between colors and information on the price badges was obtained. It could have been speculated that the color red attracts attention more readily than green (Puccinelli et al., 2013). However, as all products were presented in color, the deviation of price badge design as such served as a cue attracting attention.

Our second hypothesis proposed higher total fixation durations for food items with specifically designed price badges. Total fixation duration is usually interpreted as a measure of cognitive processing, with higher durations reflecting higher interest (Castellanos et al., 2009), deeper processing (Velichkovsky, Joos, Helmert, & Pannasch, 2005), or greater effort (Just & Carpenter, 1976). Impeccable products, serving as filler items remained relatively constant in this aspect, showing that attentional engagement on them was not influenced by

the differing appearance of the relevant items. However, relevant items were not only looked at longer when being visually suboptimal or amended with colorful price badges, but also in the impeccable version. Presumably, this effect might be due to the randomized order of trials, leading to higher interest in these products also in the baseline as compared to the filler items. Total fixation duration differed between color designs, revealing red to catch more attention than green. Taken together with the results from time to first fixation, it appears that the color red does not attract attention faster (at least in the present context), but to trigger deeper processing. Note, however, that total fixation duration is an integrated measure, that informs about processing depth, but does not differentiate between a small number of long fixations, and a large number of short fixations. Therefore, in upcoming research, we will consider bottom-up aspects of attention, re-fixations, and processing efforts separately, and in more detail.

Food appearance and price play an important role in purchase decisions (Menichelli, Olsen, Meyer, & Næs, 2012). Eye tracking allows disentangling attentional engagement on the different information (Bialkova & van Trijp, 2011). Here, we could show that attentional deployment towards price information is increased when looking at visually suboptimal food products, supporting our third hypothesis. The effect is strongest when the price badge is specifically designed, but already significantly different from surrounding impeccable items, when the price badge has exactly the same design. The message of this result is twofold: (1) Visual impairment of products is perceived as a cue of lowered quality, possibly leading to an expectation of price reduction as compensation. Therefore, more fixations are directed into the price region. (2) With distinct price labels attached to the product, automatic attention attraction and expectation interfere, leading to tremendous shifts of attention towards the price region. Highest values of attention distribution were found for price badges containing taste information. A possible explanation for this result could be an intensified balancing process of product judgment. From a methodological point of view, the spatial distinction of product and price turned out fruitful, allowing to easily disentangle attention on these two sources of information.

Testing the fourth hypothesis on choice behavior resulted in a clear pattern: When confronted with the discard question, the percentage of chosen relevant items remained stable, independently of the visual appearance. This quantitative result is also reflected in post-hoc interviews with the participants, with a common statement that, over the course of the experiment, subjects consolidated a personal ranking of the offered food items. This ranking seems indeed to be independent of visual appearance, i.e., a subject disliking bananas will dislike them in any kind of appearance. When asked for an item to purchase, choice rate drops for

visually impaired items, as has been shown before (Loebnitz, Schuitema, & Grunert, 2015). However, at least as a trend, we can show that the very same items are chosen more often to be purchased when the price badge is differently designed. Additionally, choice rate is significantly higher when the price badge carries information on a lower price, and coherently this price is also lower. Therefore, we conducted another analysis, only considering trials with price badges carrying price information and the purchase question. The 3 (condition) repeated measures ANOVA on choice behavior yielded significant differences between conditions, $F(2,58) = 16.64, p < .001, \eta^2 = .34$. Bonferroni corrected post-hoc tests revealed the difference between baseline ($M = 33.7\%$) and sub ($M = 11.8\%$), $p < .001$, and between sub and sublabel ($M = 23.4\%$), $p = .043$, to be significant. The comparison of baseline and sublabel does not reach significance level, $p = .076$. Though this still is highly speculative, these results show that there is a significant drop in acceptance of visually impaired food products when offered with regular price on a regular badge. However, when the price is reduced and the price badge informs about the bargain, the purchase rate increases, and reaches the same level as with the impeccable versions of the food product.

Taken together, the results of the present study shed some new light on the acceptance of visually impaired food products, and the chances to increase the acceptance by means of design and presentation. Differently designed price badges attract early attention and provoke deeper processing of the presented information, as compared to impeccable items with standard price badges. In the laboratory context of the study also positive effects on actual choice behavior were obtained. More and more supermarket chains in Europe take the decision to offer visually suboptimal food products to their customers. Our results suggest that attracting consumer attention towards such items can be achieved by highlighting the price badges, thereby overcoming the primary barriers against sustainable shopping behavior (Grunert, 2011). To raise the chances of a purchase decision, our results argue for a price reduction as the superior cue over the claim of sensual soundness. However, educating consumers to accept visual imperfections on food items – with taste and other quality criteria being impeccable, is the claim at hand before the background of ever increasing food waste rates (see also Loebnitz et al., 2015). The perceived availability of sustainable goods in the shelves still is low (Dickson, 2001; Vermeir & Verbeke, 2006), therefore requiring additional support in attracting consumers' attention.

5 Conclusions

We showed that specifically designed price badges drag visual attention towards suboptimal food stimuli. Although this does not necessarily result in a purchase decision, it might have an impact beyond the shopping situation: loosening the claim for perfection in the shelves may consumers make rethink their demands towards the visual appearance of food stimuli. At the end of the day consumers can make sustainable decisions only when in the shops already they get a chance to decide by themselves. A limiting factor of the current study is the intermixture of label design manipulation, product identities, and positioning within the matrix grids. Further studies will be necessary to disentangle the influences of these sources, in order to gain deeper knowledge on possibilities of attracting consumers to consider suboptimal food worth a buy.

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E.3 – Visually suboptimal bananas: How ripeness affects consumer expectation and perception

Abstract

One reason for the significant amount of food that is wasted in developed countries is that consumers often expect visually suboptimal food as being less palatable. Using bananas as example, the objective of this study was to determine how appearance affects consumer overall liking, the rating of sensory attributes, purchase intention, and the intended use of bananas. The ripeness degree (RD) of the samples was adjusted to RD 5 (control) and RD 7 (more ripened, visually suboptimal). After preliminary experiments, a total of 233 participants were asked to judge their satisfaction with the intensity of sensory attributes that referred to flavor, taste, and texture using just-about-right scales. Subjects who received peeled samples were asked after tasting, whereas subjects who received unpeeled bananas judged expectation and, after peeling and tasting, perception. Expected overall liking and purchase intention were significantly lower for RD 7 bananas. Purchase intention was still significantly different between RD 5 and RD 7 after tasting, whereas no difference in overall liking was observed. Significant differences between RD 5 and RD 7 were observed when asking participants for their intended use of the bananas. Concerning the sensory attributes, penalty analysis revealed that only the firmness of the RD 7 bananas was still not just-about-right after tasting. The importance that consumers attribute to the shelf-life of food had a pronounced impact on purchase intention of bananas with different ripeness degree. In the case of suboptimal bananas, the results demonstrate a positive relationship between the sensory perception and overall liking and purchase intention. Convincing consumers that visually suboptimal food is still tasty is of high relevance for recommending different ways of communication.

Keywords

Suboptimal food, banana, ripeness degree, just-about-right analysis, food waste, consumer

1 Introduction

In developing countries, the majority of food waste stems from insufficient conditions of storage, processing, or transportation whereas, in developed countries, it is mainly generated by the consumer (FAO, 2011; Parfitt, Barthel, & Macnaughton, 2010). Households account for approximately two thirds of the waste in the food supply chain. This equals 95 kg per head and year in Europe and 82 kg per head and year in Germany, with almost 50% being fruits and vegetables (FAO, 2011; Kranert et al., 2012). Consumers contribute to food waste (a) by selectively leaving items on supermarket shelves when, e.g., fruits show bruises, or when the best-before date is too close; (b) by discarding during consumption when the food does not meet sensory expectations, or when unexpected ingredients are detected; (c) when household stock is incorrectly estimated; (d) when knowledge on palatability is missing; and (e) because food is not valued due to the low price level. Generally speaking, consumers generate food waste either in the store when they decide what to buy, and in the household when they decide what to consume (Aschemann-Witzel, de Hooge, Amani, Bech-Larsen, & Oostindjer, 2015; Aschemann-Witzel, de Hooge, & Normann, 2016; Stefan, van Herpen, Tudoran, & Lähteenmäki, 2013). Food waste at the consumer level has a particularly negative environmental impact, as all the resources for production, transport, and preparation are wasted (Williams & Wikström, 2011).

Studies providing insight into willingness to purchase or to consume suboptimal products are scarce. Aschemann-Witzel et al. (2015) stated that “We call food products that are wasted at the consumer level even though they are edible “suboptimal foods”, defined as foods that consumers perceive as relatively undesirable as compared to otherwise similar foods because they either: (1) are close to, at or beyond the best-before date; or (2) deviate (visually or in other sensory perception) from what is regarded as optimal (usually equal to what is perceived as “normal”)“. There are only a few studies which investigate that consumers act differently towards suboptimal foods when they need to make a purchase decision in a supermarket, compared to when they need to make a consumption decision at home (de Hooge et al., 2017). The study of de Hooge et al. (2017), for instance, shows that consumer preferences for suboptimal foods differ depending on whether the consumer is in a supermarket or at home, and depending on the type of sub-optimality. In a supermarket, consumers do not want to buy too long ripened foods at regular price. In contrast, when consumers detect too long ripened food at home, they may want to use it to avoid losing money (as the food was already bought).

The first contact between consumer and food is usually through the visual impression of intrinsic or extrinsic product attributes. Many studies investigated influences of intrinsic or extrinsic product attributes on food liking, food intake, food consumption, purchase intention, or sensory expectations (e.g., Carrillo, Varela, & Fiszman, 2012; Mai, Symmank, & Seeberg-Elverfeldt, 2016; Zellner, Loss, Zearfoss, & Remolina, 2014). However, for both intrinsic and extrinsic attributes only a few studies examined consumer evaluation of visually suboptimal foods in the light of sustainability. For instance, White, Lin, Dahl, & Ritchie (2015) demonstrated that consumers avoid products with superficial packaging damage as this implies contamination and generates safety concerns. Loebnitz & Grunert (2015) focused on shape abnormalities of apples, lemons, carrots and eggplants as intrinsic cue to examine purchase intention, and Bunn, Feenstra, Lynch, & Sommer (1990) reported on low acceptance of imperfect oranges. Based on the assumption that consumers associate food abnormalities with low quality, it is common practice to remove foods that do not follow an appearance standard (e.g. shape, color, size) from shelves in retail outlets. In turn, due to the availability of regular low price alternatives, retailers do not consider putting suboptimal products on their shelves (Aschemann-Witzel, de Hooge, & Normann, 2016).

Recent research called to examine how sensory impressions based on criteria other than shape influence buying intention (Loebnitz & Grunert, 2015). In fruits and vegetables, for example, color serves as indicator for the progress of ripening or even decay. Hence, color as part of the “natural packaging” of a food gives a first visual impression that usually generates expectations of flavor, texture, or overall quality (Bello Acebrón & Calvo Dopico, 2000; Wei, Ou, Luo, & Hutchings, 2012). A prominent example is bananas which, in the context of ripening, have been studied with respect to peel color, texture, and biochemical changes (Bugaud et al., 2013; Facundo, Gurak, Mercadante, Lajolo, & Cordenunsi, 2015; Gomes, Vieira, & Leta, 2013; Jaiswal et al., 2012; Salvador, Sanz, & Fiszman, 2007). More recent research focused on the sensory description of bananas (Bugaud et al., 2011; Nunes, Yagiz, & Emond, 2013; Tobin, Moane, & Larkin, 2013). To the best of our knowledge, only one study analyzed bananas in context with food waste, and determined what was called the banana waste critical point (Nannyonga, Bakalis, Andrews, & Gkatzionis, 2016). Bananas can be classified on the basis of the peel color into seven ripeness degrees, usually assigned by using a standardized color chart: (1) totally green; (2) green with yellow traces; (3) more green than yellow; (4) more yellow than green; (5) yellow with green edges; (6) totally yellow; and (7) yellow with brown spots (Von Loesecke, 1950).

With regard to the consumers' food waste behavior, an important motivation for discarding fruits and vegetables is the presence of visual defects. Using bananas as model, the objective of the study was to show how visual exposure influences expectation and perception of the food. Depending on whether a visually suboptimal or a regular product is inspected, we analyze overall liking, the rating of sensory attributes, purchase intention, and the intended use of bananas. The current research will provide insights into both the supermarket setting (by revealing overall liking and purchase intention of unpeeled bananas based on visual exposure only), and the home situation. The home situation is considered in two ways: First, consumers generate expectations of the unpeeled banana with different degrees of ripeness, depending on the duration of home storage. Subsequently, consumers evaluate overall liking and re-purchase intention based on sensory perception of the (self-)peeled banana. As consumer general food waste behavior has been shown to depend on gender (Koivupuro et al., 2012), this study also aims at analyzing differences in the responses between males and females.

2 Material and methods

2.1 Recruitment of participants

To recruit participants, email newsletters with the slogan 'Taste it? Your senses will help us!' were sent to student representatives of Technische Universität Dresden with a request to distribute it in their respective channels, and announcements were placed in cafeterias and bulletin boards across the campus. Prospective participants were asked to register on a web page. Individuals from this pool were contacted, and finally 233 participants took part in the study (140 male and 93 female, mean age 22.2 ± 3.1 years). All participants received written information about the study before giving their informed consent. However, the participants were not informed beforehand which particular product they were about to taste, and no information on the study aim was provided.

2.2 Stimuli material: Bananas

For preliminary experiments, we bought bananas of ripeness degree (RD) 3 - 4 from a regional fruits and vegetables wholesaler (Landgard, Dresden, Germany). According to the wholesaler, this is the ripeness degree in which the bananas are usually sold to the supermarkets. The bananas were stored at 20 °C (Quevedo et al., 2008) in an environmental chamber (IPP 55, Memmert GmbH & Co. KG, Schwabach, Germany). Banana peel color was compared daily with the color chart by the author to record banana ripeness. After three days of

storage the bananas reached RD 5 (yellow with green edges) and after seven days the first brown spots were visible that is typical for RD 7. Bananas of RD 7 are no longer sold in the supermarket. For the main study, the bananas were purchased some time in advance to ensure that, on the day of investigation, samples with RD 5 and RD 7 were available (Fig. 1).

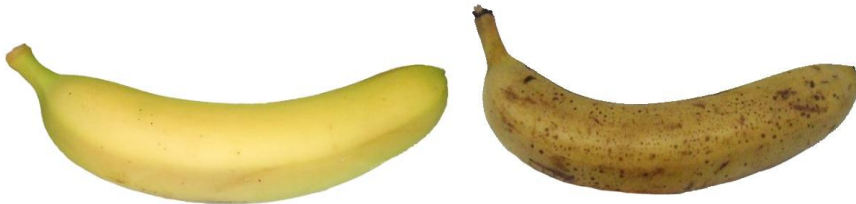


Fig. 1. Example of the bananas of ripeness degree 5 (left) and 7 (right).

2.3 Experiment design

Each of the 233 participants contributing to the study was randomly assigned to one of four test conditions. Fig. 2 shows that group 1 (G 1) and group 2 (G 2) subjects received one peeled banana of either RD 5 or RD 7, to immediately rate overall liking, the perception of sensory attributes during tasting, purchase intention, and intended use of the banana (blind condition). Group 3 (G 3) and group 4 (G 4) subjects received an unpeeled banana of either RD 5 or RD 7. In a first step, they were encouraged to rate overall liking, the expected satisfaction with the intensity of sensory attributes, purchase intention, and intended use of the banana based on visual impression. In a second step, the participants had to peel and taste the banana, and to rate again overall liking, the perceived satisfaction with the intensity of sensory attributes, purchase intention, and intended use of the banana (expected and informed condition).

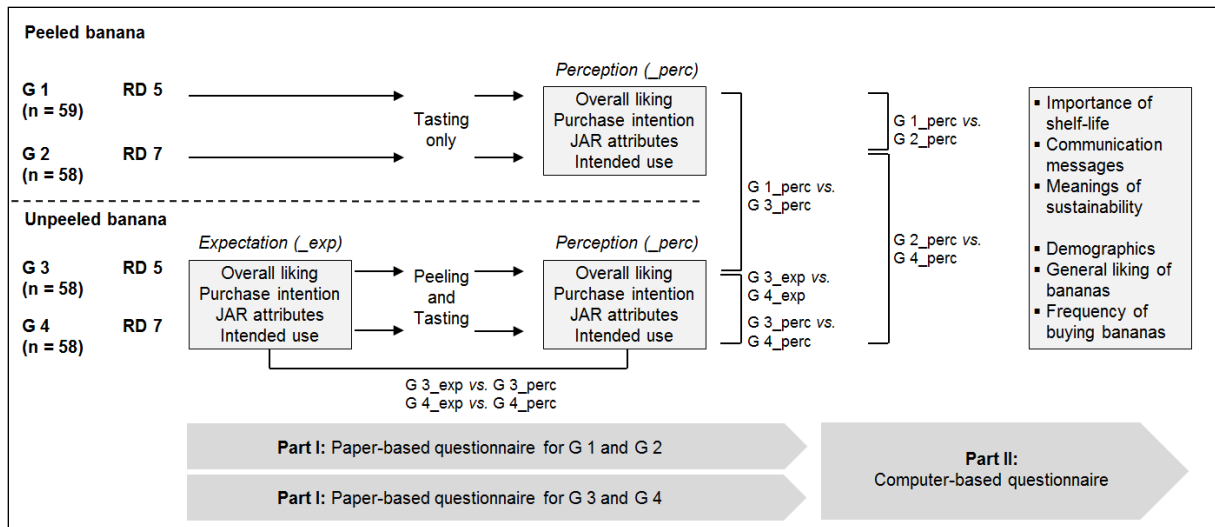


Fig. 2. Layout of the experiment design of the study ($n = 233$) and overview of comparisons tested in this study; RD, ripeness degree; G 1, peeled banana of RD 5; G 2, peeled banana of RD 7; G 3, unpeeled banana of RD 5; G 4, unpeeled banana of RD 7; suffix *_exp* is for expectation, *_perc* for perception.

The experiment design allows (a) to explore the impact of banana peel color as a cue on expectation and perception within one ripeness degree (G 3_exp vs. G 3_perc, G 4_exp vs. G 4_perc), (b) to examine the differences in the perception of bananas of a particular ripeness degree (G 1_perc vs. G 3_perc, G 2_perc vs. G 4_perc), which arise from visual confrontation with the peel, and (c) to identify differences in expectation (G 3_exp vs. G 4_exp) and perception (G 1_perc vs. G 2_perc, G 3_perc vs. G 4_perc) that can be attributed to the ripeness degree itself (Fig. 2). We also checked differences in the expectations and perception between males and females.

In Part II of the study (Fig. 2) information about demographics, general liking, and buying frequency were collected. Table 1 provides an overview of the demographic characteristics of each experimental group (G 1, G 2, G 3, G 4). To avoid an unintended bias between the experimental groups, we conducted an ANOVA to analyze whether there are differences in the liking of bananas between the experimental groups. The liking was judged using a two-item (“In general, I like bananas” and “I like eating bananas”) seven-point scale. An index was calculated as the mean of the two items (6.0 ± 1.3 , $\alpha = 0.90$). This analysis revealed no significant difference in the liking between the experimental groups ($F_{3,229} = 1.56$, $p = 0.200$). Using a chi-squared test we have also tested whether the general buying frequency of bananas (with the response categories “never or occasionally”, “once or twice a month”, “once or twice a week”, and “daily”) is different between the experimental groups. This effect was not significant ($\chi^2 = 5.68$, $df = 9$, $p = 0.772$).

Table 1. Demographic characteristics of the four experimental groups.

| Group | Age (mean \pm standard deviation)* | Female participants (%) |
|--------------|--------------------------------------|-------------------------|
| G 1 (n = 59) | 22.3 \pm 3.5 ^a | 44.1 |
| G 2 (n = 58) | 22.4 \pm 3.4 ^a | 48.3 |
| G 3 (n = 58) | 21.8 \pm 2.5 ^a | 31.0 |
| G 4 (n = 58) | 22.5 \pm 3.0 ^a | 36.2 |

* Mean values in a column with different superscripts differ significantly ($p < 0.05$).

Testing took place in a sensory laboratory, designed in accordance with ISO guidelines (ISO, 2007), under artificial daylight and at constant temperature (22 ± 1 °C). For the sensory evaluation of the bananas (Part I, Fig. 2), participants were seated in individual booths. Once the participants had completed the sensory task, they were asked to complete an electronic questionnaire (Part II, Fig. 2) programmed in LimeSurvey (LimeSurvey GmbH, Hamburg, Germany). After completing the study participants were thanked, debriefed, and paid.

2.4 Questionnaire development and scales

Affective assessment of banana *overall liking* was done using a nine-point hedonic scale with the anchors “dislike extremely” and “like extremely” (Peryam & Pilgrim, 1957). The *intention to purchase* the banana was judged using a two-item (“I would buy this banana” and “Next time I buy a banana, I will buy a banana like this”) seven-point scale, anchored by “strongly disagree” to “strongly agree” (Putrevu & Lord, 1994).

Sensory expectation and perception are important influencing factors of food choice and behavior (Krishna, 2012). Therefore, to identify *sensory perception* of peeled bananas, *expectation* of unpeeled bananas, and then sensory perception after self-peeling, grassy flavor, banana flavor, sweetness, firmness and mealiness were measured with bipolar five-point just-about-right (JAR) scales (1, too low; 2, somewhat too low; 3, just-about-right; 4, somewhat too high; and 5, too high; Meilgaard, Carr, & Civille, 2006). The five-point JAR scale was subsequently converted into a three-point scale with the values 1 (summary of 1 and 2), 2 (scale midpoint) or 3 (summary of 4 and 5) for the categories “too low”, “just-about-right” or “too high”, respectively (Gere, Sipos, & Héberger, 2015; Popper, 2004). The five JAR questions were printed on the back of an A4 sheet so that an impact on overall liking judgment (front of the same A4 sheet) was reduced (Gacula, Mohan, Faller, Pollack, & Moskowitz, 2008).

Subsequently, participants had to indicate the *intended use of bananas*. They were asked whether the banana should be consumed as soon as possible, whether the banana could

be more ripened, and whether they would only use this banana for cooking, baking, or dessert preparation on a seven-point scale from “strongly disagree” to “strongly agree”.

The computer-based questionnaire was the same for each experimental group (Part II, Fig. 2). Forty-six statements to identify food purchasing habits, attitudes towards food waste and sustainability were adapted from literature and measured with seven-point scales from “strongly disagree” to “strongly agree”. We decided to report the data for *shelf-life*. The other survey data are not part of this paper. The scale for shelf-life was recently developed within the research project and has not yet been published elsewhere. Shelf-life was measured using a four-item (“I prefer to choose foods with the longest freshness date”, “I frequently buy food close to the best-before date, if it is offered at a lower price”, “I compare date labels to select food with the longest shelf life”, and “I deliberately buy food close to the best-before date when I know that I will consume it soon”) seven-point scale, anchored by “strongly disagree” to “strongly agree”.

To reveal which *communication messages* would stimulate the purchase of bananas with brown spots, a picture (Fig. 1, right) was included in the questionnaire software (as not each participant received an unpeeled banana of RD 7). Participants ticked all the appropriate messages using a check-all-that-apply (CATA) list with seven possible responses (Table 2). The statements for this CATA list were developed within the research project. The *meanings of sustainability* in context with food were also evaluated using a CATA list with sixteen possible responses (Table 2). This CATA list was developed based on Reisch, Eberle, & Lorek (2013). For both, the number of selected responses was divided by the total number of participants to obtain the share of participants who agree with the statement.

Table 2. CATA lists for communication messages and meanings of sustainability.

| Communication messages | Meanings of sustainability | |
|--|---|--|
| – To be consumed quickly. | – Fair trade products | – Environmentally compatible packaging |
| – Don’t make me go to food waste. | – Organic food | – Little packaged products |
| – As intended by nature. | – Vegetarian food | – Buying regional food |
| – The looks might not be perfect, the taste is! | – Vegan food | – Buying seasonal food |
| – 50% off. | – Shop at the weekly market | – Food which improves health |
| – Take me with you, for the sake of the environment. | – Avoiding food waste | – Food free from genetic engineering |
| – None of the messages would make me buy this product. | – Eating less meat | – Food free from flavor enhancers |
| | – Eating a lot of fresh food / eating less processed food | – Other aspect: |

To ensure linguistic equivalence, the back-translation procedure was applied (Brislin, 1970). Questionnaire format was validated by a pilot survey that was conducted prior to the main study with 30 students during a lecture to check whether all questions of the survey are correctly understood, and to estimate the time it will take to complete the questionnaire. The main consumer survey started after editing, electronic programming, and additional pre-testing of the electronic version of the questionnaire.

2.5 Development of sensory descriptors

To identify sensory properties for the main study that are different between bananas of RD 5 and RD 7, a set of two-alternative forced choice (2-AFC) tests (ISO, 2005) with 35 semi-trained participants (i.e., members of the institute who had received a basic training with respect to perceive intensity differences of sensory attributes (ISO, 2012)), was performed using ten descriptors from literature (for details see Appendix A). Five remaining attributes selected to be used in this study were therefore: grassy flavor, referring to the flavor of freshly cut green grass; banana flavor; sweetness; firmness, referring to the force necessary to compress a sample between the teeth; and mealiness, referring to an abnormal softness, lack of free juice, and a pasty, dry feeling in the mouth (Bianchi et al., 2016; Blaker, Plotto, Baldwin, & Olmstead, 2014; Bugaud et al., 2011; Nobile et al., 2011).

2.6 Analytical validation of banana ripeness

The study focus was to evaluate sensory descriptors of banana appearance, flavor, and texture, by either including the visual impression of the banana peel or not. It was therefore necessary to ensure that the participants assigned to a group received similar bananas, that means, bananas with comparable physical and chemical properties. If there was any reported difference between peeled and unpeeled bananas, it could be attributed to the banana peel and not to any actual differences of the banana itself. In addition, the two ripeness degrees were needed that differ in appearance.

Based on prior studies (Bugaud et al., 2013; Liew & Lau, 2012; Nannyonga et al., 2016; Tapre & Jain, 2012), banana color, firmness of peel and flesh, and sugar content were identified as appropriate analytical parameters to distinguish between bananas of different ripeness degrees. For a detailed description of the methods, please refer to Appendix B.

2.7 Statistical analyses

Statistical analysis of analytical parameters and questionnaire responses was conducted using SPSS 23 (IBM Deutschland GmbH, Ehningen, Germany).

For purchase intention, an index was calculated as the mean of the two items (pre-tasting: 4.9 ± 1.6 , $\alpha = 0.89$; post-tasting: 5.2 ± 1.5 , $\alpha = 0.83$). Two-tailed paired and independent sample t-tests were computed to check differences in overall liking and purchase intention between or within the experimental groups as well as between males and females.

A two-tailed one-sample t-test was applied to evaluate whether the mean JAR ratings of each sensory attribute differ from scale midpoint (2.0) at $p \leq 0.05$ (Pitts, 2009). To determine whether JAR ratings are associated with a drop in spontaneous overall liking, a subsequent penalty analysis was performed. For the penalty analysis, we calculated the mean drop as the difference between the average overall liking score for the subjects who selected a non-JAR category, and the average overall liking score for the subjects who judged the attribute as just-about-right (Pagès, Berthelo, Brossier, & Gourret, 2014). A common interpretation is that mean drops between -1 and -2 indicate that the sensory attribute can be regarded as being responsible for a decrease in overall consumer liking (Schraidt, 2009). The distribution of the responses in the categories “too low”, “just-about-right” and “too high” may be taken into account as additional indicator to identify attributes that are on an undesired level (Hoppert et al., 2013; Schraidt, 2009). A distribution with more than 20% of responses on the “too low” or “too high” side indicates a need for optimization in that attribute (Schraidt, 2009).

For the importance of shelf-life, an index was calculated as the mean of the four items (3.9 ± 1.2 , $\alpha = 0.55$). According to Gliem & Gliem (2003) a Cronbach’s alpha with 0.5 or higher is sufficient. Subsequently, an ANOVA was conducted to check interaction effects between the importance of the shelf-life and banana ripeness. Tukey-Kramer was used as post hoc test.

3 Results

3.1 Characteristics of the test materials

The analytical measurements of the bananas showed that the color of the banana peels, the firmness of unpeeled and peeled bananas, and the sugar content differed significantly between bananas with RD 5 and RD 7. The respective data are summarized and interpreted in line with the results of the preliminary experiments in Appendix B.

3.2 Overall liking and purchase intention

Paired sample t-tests, calculated to reveal differences between expectation and perception within one ripeness degree, showed no significant differences in overall liking ($t_{57} = 1.30$, $p = 0.199$) and purchase intention ($t_{57} = 0.17$, $p = 0.867$) for RD 5 bananas before and after tasting (G 3_exp vs. G 3_perc). For bananas of RD 7, participants expressed their low expectations with significant lower overall liking ($t_{57} = 5.27$, $p < 0.001$) and purchase intention before tasting ($t_{57} = 3.84$, $p < 0.001$) compared to the ratings of overall liking and purchase intention after tasting (G 4_exp vs. G 4_perc). In the comparison of bananas of the same ripeness degree, independent sample t-tests yielded neither significant differences for overall liking (G 1_perc vs. G 3_perc: $t_{115} = 0.38$, $p = 0.708$; G 2_perc vs. G 4_perc: $t_{114} = 0.67$, $p = 0.505$), nor for purchase intention (G 1_perc vs. G 3_perc: $t_{115} = 0.04$, $p = 0.971$; G 2_perc vs. G 4_perc: $t_{114} = 1.08$, $p = 0.281$). All respective results are presented in Table 3.

Table 3. Means and standard deviations of overall liking and purchase intention in all experimental groups, and results of the independent sample t-tests for gender differences.

| Experiment set-up* | Total | Male (m) | Female (f) | p (m ↔ f) |
|-------------------------------------|------------------|------------------|------------------|-----------|
| Expectation – before tasting | | | | |
| Overall liking | | | | |
| G 1_exp (RD 5) | - | - | - | |
| G 2_exp (RD 7) | - | - | - | |
| G 3_exp (RD 5) | 7.2±1.1 (n = 58) | 7.1±1.1 (n = 40) | 7.4±1.1 (n = 18) | 0.207 |
| G 4_exp (RD 7) | 6.3±1.6 (n = 58) | 6.8±1.4 (n = 37) | 5.5±1.6 (n = 21) | 0.004 |
| Purchase intention | | | | |
| G 1_exp (RD 5) | - | - | - | |
| G 2_exp (RD 7) | - | - | - | |
| G 3_exp (RD 5) | 5.4±1.3 (n = 58) | 5.3±1.3 (n = 40) | 5.6±1.4 (n = 18) | 0.420 |
| G 4_exp (RD 7) | 4.4±1.7 (n = 58) | 4.9±1.5 (n = 37) | 3.4±1.5 (n = 21) | ≤ 0.001 |
| Perception – after tasting | | | | |
| Overall liking | | | | |
| G 1_perc (RD 5) | 7.0±1.4 (n = 59) | 7.1±1.3 (n = 33) | 6.9±1.5 (n = 26) | 0.651 |
| G 2_perc (RD 7) | 7.2±1.2 (n = 58) | 7.4±1.0 (n = 30) | 6.9±1.4 (n = 28) | 0.066 |
| G 3_perc (RD 5) | 6.9±1.6 (n = 58) | 7.0±1.5 (n = 40) | 6.7±1.8 (n = 18) | 0.426 |
| G 4_perc (RD 7) | 7.3±1.3 (n = 58) | 7.8±0.8 (n = 37) | 6.4±1.5 (n = 21) | ≤ 0.001 |
| Purchase intention | | | | |
| G 1_perc (RD 5) | 5.5±1.3 (n = 59) | 5.4±1.3 (n = 33) | 5.6±1.4 (n = 26) | 0.635 |
| G 2_perc (RD 7) | 5.2±1.4 (n = 58) | 5.3±1.4 (n = 30) | 5.1±1.4 (n = 28) | 0.632 |
| G 3_perc (RD 5) | 5.5±1.4 (n = 58) | 5.5±1.5 (n = 40) | 5.4±1.5 (n = 18) | 0.888 |
| G 4_perc (RD 7) | 4.9±1.6 (n = 58) | 5.5±1.4 (n = 37) | 4.0±1.6 (n = 21) | ≤ 0.001 |

* G 1, peeled banana of ripeness degree (RD) 5; G 2, peeled banana of RD 7; G 3, unpeeled banana of RD 5; G 4, unpeeled banana of RD 7; suffix _exp is for expectation, _perc for perception.

As regards differences in the expectation affected by the ripeness degree, overall liking (G 3_exp vs. G 4_exp; $t_{114} = 3.49$, $p = 0.001$) and purchase intention ratings (G 3_exp vs. G 4_exp; $t_{114} = 3.79$, $p < 0.001$) of the unpeeled fruits was significantly lower for RD 7 bananas after visual judgment alone. Whereas, after tasting, no significant difference in overall liking ($t_{114} = 1.48$, $p = 0.141$) was found between RD 5 and RD 7 bananas (G 3_perc vs. G 4_perc). However, purchase intention ratings were still significant ($t_{114} = 1.91$, $p = 0.059$) with a lower purchase intention for the RD 7 banana compared to the RD 5 banana. Presumably, the participants favored the bananas based on the tasting experience, but this liking did not turn into a positive purchase intention because of the initial visual impression. Neither a significant difference was observed between perception ratings for the peeled banana (G 1_perc vs. G 2_perc), nor for overall liking ($t_{115} = 0.58$, $p = 0.567$), nor for purchase intention ($t_{114} = 1.01$, $p = 0.313$).

Independent sample t-tests were also computed to check differences in overall liking and purchase intention between males and females (Table 3). For the unpeeled banana of RD 5 (G 3_exp, G 3_perc), no significant difference between males and females for overall liking and purchase intention was found, neither before nor after tasting. Regarding the unpeeled RD 7 bananas (G 4), a significant gender effect was observed: Before (G 4_exp) and after tasting (G 4_perc), males expressed a significantly higher overall liking (before: $t_{56} = 3.10$, $p = 0.004$; after: $t_{56} = 3.83$, $p < 0.001$) and purchase intention (before: $t_{56} = 3.60$, $p = 0.001$; after: $t_{56} = 3.79$, $p < 0.001$). Regarding the peeled bananas of RD 5 (G 1_perc), no significant differences in overall liking and purchase intention between males and females were observed. The same could be observed for the RD 7 bananas (G 2_perc).

3.3 Influence of the sensory attributes on overall liking

Arithmetic means and standard deviations were calculated for each experimental group and each attribute (Table 4). The RD 5 banana was expected (unpeeled before tasting) and perceived (after tasting) as being “too high in grassy flavor” and “too high in firmness” (G 3), and it was expected and perceived as being “too low in banana flavor” and “too low in sweetness”. Also the peeled banana of RD 5 was perceived as being “too low in banana flavor” and “too low in sweetness” (G 1). For RD 7 the results show that both, the peeled and the unpeeled banana, was expected and perceived to be “too low in firmness” and “too high in mealiness” (G 2, G 4). Concerning banana flavor and sweetness, the unpeeled RD 7 banana before tasting was expected to be “too high” in these attributes (G 4). After tasting, only sweetness was judged as “too high”, whereas banana flavor was close to scale midpoint (G 4). The grassy flavor was expected to be “too low” for the unpeeled banana of RD 7 (G 4).

Table 4. Average just-about-right (JAR) ratings for peeled and unpeeled bananas of ripeness degree (RD) 5 and RD 7 under different experimental conditions.

| Experiment set-up* | Grassy flavor** | Banana flavor | Sweetness | Firmness | Mealiness |
|-------------------------------------|------------------|------------------|------------------|------------------|------------------|
| Expectation – before tasting | | | | | |
| G 3_exp (RD 5) | 2.2 ± 0.7 | 1.7 ± 0.6 | 1.5 ± 0.6 | 2.4 ± 0.6 | 2.0 ± 0.6 |
| G 4_exp (RD 7) | 1.6 ± 0.6 | 2.3 ± 0.5 | 2.3 ± 0.6 | 1.5 ± 0.6 | 2.4 ± 0.6 |
| Perception – after tasting | | | | | |
| G 1_perc (RD 5) | 2.1 ± 0.6 | 1.4 ± 0.5 | 1.5 ± 0.6 | 2.0 ± 0.6 | 2.0 ± 0.5 |
| G 2_perc (RD 7) | 1.9 ± 0.6 | 2.0 ± 0.6 | 2.1 ± 0.7 | 1.6 ± 0.6 | 2.4 ± 0.6 |
| G 3_perc (RD 5) | 2.2 ± 0.6 | 1.5 ± 0.5 | 1.5 ± 0.6 | 2.2 ± 0.6 | 1.9 ± 0.5 |
| G 4_perc (RD 7) | 1.9 ± 0.5 | 2.1 ± 0.5 | 2.2 ± 0.5 | 1.6 ± 0.5 | 2.5 ± 0.5 |

* G 1, peeled banana of ripeness degree (RD) 5; G 2, peeled banana of RD 7; G 3, unpeeled banana of RD 5; G 4, unpeeled banana of RD 7; suffix _exp is for expectation, _perc for perception.

** Values are the arithmetic mean ± standard deviation; attributes measured with a five-point JAR scale, which was converted into a three-point JAR scale from “too low” over “just-about-right” to “too high”; mean values in bold differ significantly with $p < 0.05$ from scale midpoint (2.0).

The penalty analysis (Fig. 3) reveals that the peeled RD 5 banana was perceived as “too low in banana flavor” and “too low in sweetness” but as “too high in grassy flavor” (G 1_perc). The unpeeled RD 7 banana (G 4_exp) was expected as being “too high in banana flavor” and “too high in sweetness”, and as “too low in firmness”. After tasting (G 4_perc), only firmness was perceived as “too low” for the same product. In the context of the promotion of visually suboptimal bananas this means that only firmness expectation of more ripened bananas negatively influences overall liking, so that the other tested attributes might help to communicate messages that intend to strengthen purchase and consumption. For the unpeeled RD 5 (G 3_exp, G 3_perc) and the peeled RD 7 bananas (G 2_exp, G 2_perc), the mean drops in combination with the percentage of ratings revealed no concerning attributes, neither before nor after tasting.

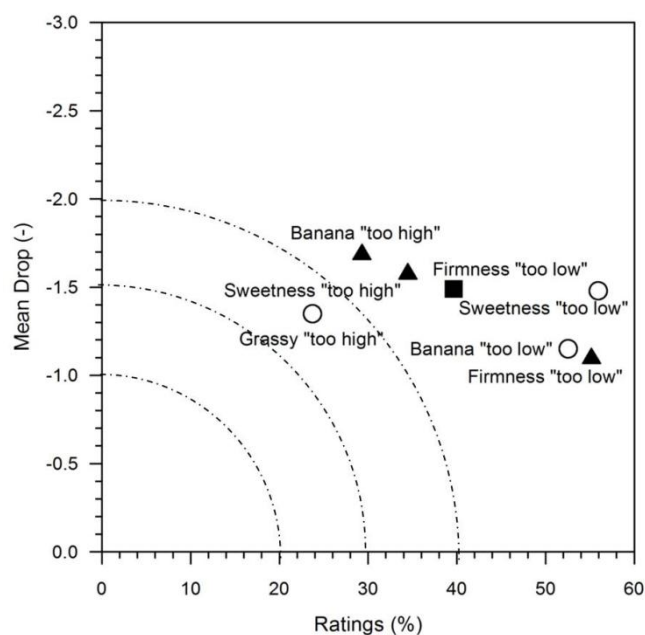


Fig. 3. Mean drops of attributes as a function of just-about-right ratings. Only attributes with more than 20% of responses on the “too low” or “too high” side and a mean drop lower than -1 are plotted. ○, peeled RD 5 banana after tasting; ▲, unpeeled RD 7 banana before tasting; ■, unpeeled RD 7 banana after tasting.

3.4 Intended use of suboptimal bananas

Participants who received unpeeled bananas were, before tasting (G 3_exp and G 4_exp), asked whether these should be consumed as soon as possible (Fig. 4) which was affirmed by significant more participants who received the RD 7 banana ($t_{114} = 7.30$, $p < 0.001$). Consistent results were obtained when participants were asked directly whether the banana could be more ripened, which was denied by participants who received RD 7 bananas ($t_{114} = 5.27$, $p < 0.001$). Based on visual impression, the denoted usage for only cooking, baking, or dessert preparation was significantly higher for RD 7 bananas ($t_{114} = 2.70$, $p = 0.008$). However, the relatively low mean values indicate that both bananas are not really considered for cooking, baking, or dessert preparation. After tasting, all participants (those who received a peeled banana, G 1_perc and G 2_perc, and those who received an unpeeled banana, G 3_perc and G 4_perc) were (again) asked whether the banana should be consumed as soon as possible. In both conditions, significant differences (G 1_perc vs. G 2_perc: $t_{114} = 2.55$, $p = 0.012$; G 3_perc vs. G 4_perc: $t_{114} = 7.46$, $p < 0.001$) were obtained. In the evaluation of whether the bananas could be more ripened, the peeled banana of RD 7 (G 2_perc) differed significantly from RD 5 (G 1_perc vs. G 2_perc: $t_{114} = 3.07$, $p = 0.003$), and a further significant drop was observed when the participants based their judgment on the visual impression of the RD 7 banana peel (G 3_perc vs. G 4_perc: $t_{114} = 7.08$, $p < 0.001$). Finally, after tasting, participants who received the unpeeled banana would prefer to use RD 7

instead of RD 5 bananas for cooking, baking, or dessert preparation (G 3_perc vs. G 4_perc: $t_{114} = 2.74$, $p = 0.008$).

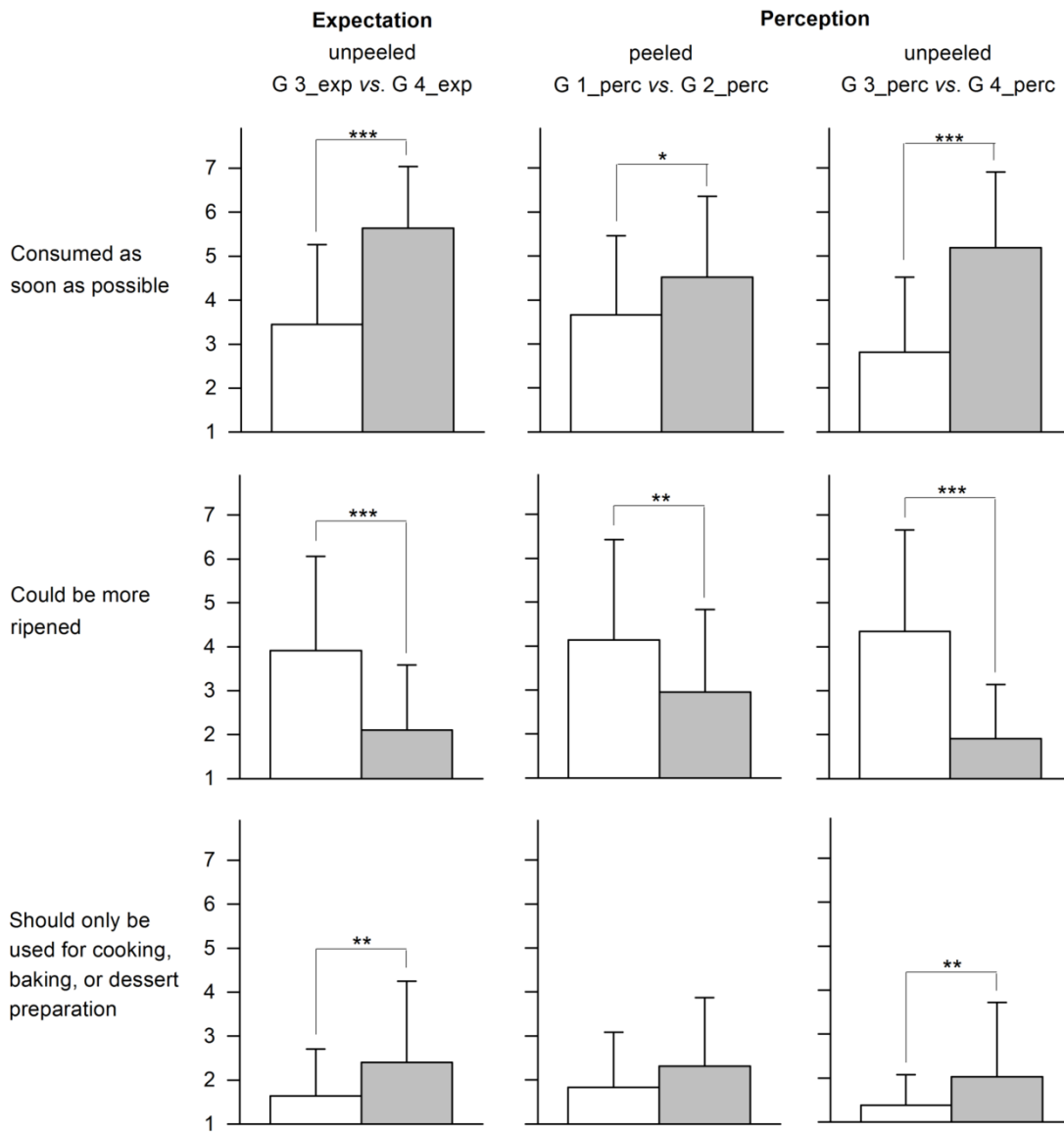


Fig. 4. Means and standard deviations of participants' responses regarding the intended use of bananas depending on the ripeness degree (RD) and the time of judgment. White bars, RD 5; grey bars, RD 7; G 1, peeled banana of RD 5; G 2, peeled banana of RD 7; G 3, unpeeled banana of RD 5; G 4, unpeeled banana of RD 7; suffix _exp for expectation, _perc for perception; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

3.5 Importance of shelf-life as influencing factor of food waste behavior

We further classified consumers of the experimental groups G 3 and G 4, i.e. who received an unpeeled banana, based on the importance they attribute to the shelf-life of foods. As regards purchase intention responded before tasting, an ANOVA yielded a significant interaction effect between the importance of the shelf-life and banana ripeness ($F_{1,112} = 9.52$,

$p = 0.003$). Those consumers who preferred food with a long shelf-life expressed a higher purchase intention for RD 5 bananas (5.8 ± 0.9 ; Fig. 5) than for RD 7 bananas (3.8 ± 1.7), whereas consumers who do not care about the shelf-life have a higher purchase intention for RD 7 (4.9 ± 1.5) than for RD 5 bananas (5.2 ± 1.5). The same significant interaction effect was obtained for purchase intention after tasting ($F_{1,112} = 7.40$, $p = 0.008$) with consumers preferring food with a long shelf-life expressed a higher purchase intention for RD 5 bananas (5.9 ± 1.1) than for RD 7 bananas (4.5 ± 1.5), whereas consumers who do not care about the shelf-life have a higher purchase intention for RD 7 (5.3 ± 1.6) than for RD 5 bananas (5.2 ± 1.5).

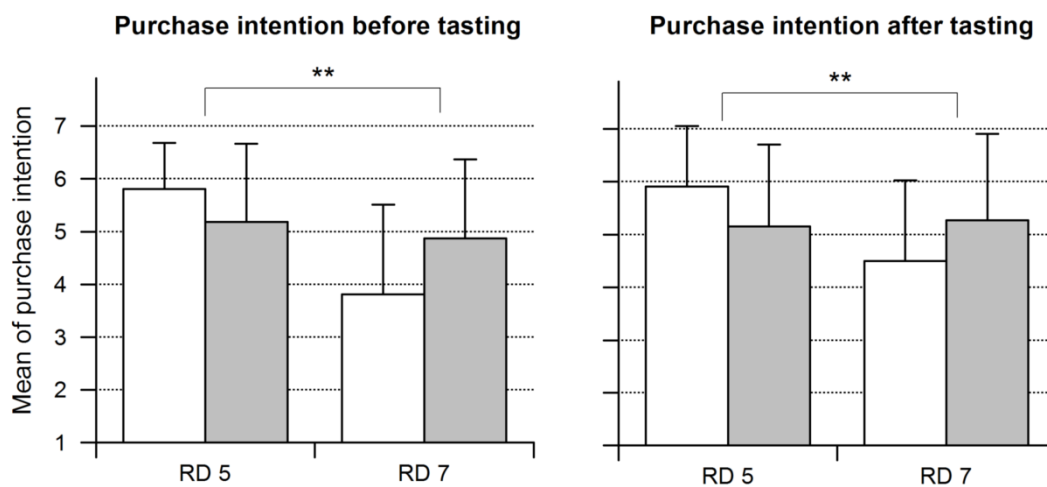


Fig. 5. Means and standard deviations of purchase intention ratings before (left) and after (right) tasting of the experimental groups G 3 (unpeeled banana of RD 5) and G 4 (unpeeled banana of RD 7) depending on the importance of shelf-life and ripeness degree (RD). White bars, shelf-life important, $n = 50$; grey bars, shelf-life not important, $n = 66$; $**p < 0.01$.

3.6 Communication messages and meanings of sustainability

The analysis of the check-all-that-apply questions shows that price reduction (for 63.9% of the participants), immediate consumption intention (57.5%), and positive taste inferences (53.2%) are messages that may stimulate the purchase of bananas with brown spots. There are still 38.6% of the participants who would take the banana before it goes to food waste. The other messages were marked by only 30% or less. An important finding particularly with regard to food waste reduction is that any message is better than no message (3%). Finally, participants disclose what sustainability means to them in context with food: Besides purchasing regional (67.0%) and seasonal food (63.1%), the avoidance of food waste was mentioned as important by 61.8% of the subjects, even though they were not informed about the objective of our study. More than half of the participants prefer environmentally friendly

packages (55.8%), and would like to buy food with as little packaging as possible (59.7%). The other meanings of sustainability were marked by 40% or less.

4 Discussion and conclusions

The results of this study support the assumption that appearance influences the expected and perceived satisfaction with the intensity of sensory attributes, but also overall liking and purchase intention. In the case of bananas, overall liking and purchase intention decreased when the product exceeded a certain ripening status. Considering the supermarket setting, consumers are more likely to purchase yellowish-green bananas than bananas with brown spots, which clearly implies that visual defects decrease consumer liking and the intention to buy the food (de Hooze et al., 2017). After the bananas have been tasted as in the home situation, no significant difference in overall liking was found between both ripeness degrees, whereas (re-)purchase intention was still significantly lower for RD 7 bananas. This demonstrates that sensory perception can drive consumer liking. However, purchase intention of apparently suboptimal foods remains influenced by the initial visual impression.

The results also show that males have a higher overall liking and purchase intention of the unpeeled RD 7 bananas before and after tasting, and a higher overall liking of the peeled RD 7 banana after tasting. Previous research suggests that consumer preferences for suboptimal products and the general food waste behavior may depend (apart from situational factors, type of sub-optimality, etc.) on personal factors, e. g., gender (Katajajuuri, Silvennoinen, Hartikainen, Heikkilä, & Reinikainen, 2014; Koivupuro et al., 2012). For example, Katajajuuri et al. (2014) indicate that the amount of avoidable food waste was considerably lower in those households where a man was mainly responsible for grocery shopping in comparison with households where only a woman or both were responsible. Gender differences regarding suboptimal food choice need to be further investigated in future research. Follow-up studies could also investigate whether these differences also occur in a non-student sample and in the case of different food.

The observed discrepancy between expectation and perception is consistent with previous studies that investigated the effect of extrinsic or intrinsic attributes on product evaluation (Carrillo et al., 2012; Laureati, Conte, Padalino, Del Nobile, & Pagliarini, 2016). The results of the penalty analyses showed that peeled RD 7 bananas are just-about-right in each sensory attribute. However, when participants expressed their expectation based on the visual impression of an unpeeled RD 7 banana, banana flavor and sweetness were judged as being “too high”, whereas firmness was rated “too low”. After tasting, only firmness remained to be

not just-about-right. To enhance the acceptance of bananas with brown spots it seems therefore appropriate to emphasize sensory attributes regarding flavor and smell.

Our data suggest that price reduction, immediate consumption intention and positive taste inferences may stimulate the intention to purchase bananas with brown spots. To date, price discounts have often been researched as a tool to stimulate the purchase of healthy foods (Ball et al., 2015; Juhl & Jensen, 2014). However, price reduction on suboptimal foods as possibility to reduce food waste received far less attention. Consumers consider food waste reduction as sustainable as it was, after regional and seasonal purchase, the third often mentioned category of sustainable food behavior. Although it seems to be in the consciousness of the consumers, the amount of food waste suggests that these attitudes do not turn into real behavior (Stefan et al., 2013).

Communication campaigns and education programs should be encouraged and pooled to continuously increase the willingness of consumers to buy (supermarket setting) and consume (home situation) suboptimal foods and to fight food waste. Despite the abolishment of official quality standards in the supermarket, a common retail practice is to discard food that exceeds a supposed optimum quality because retailers are afraid that consumers may reject it (Loebnitz & Grunert, 2015). Our results demonstrate a positive relationship between sensory perception, overall liking, and purchase intention for suboptimal bananas – this means that there are consumers who will buy suboptimal bananas when they are convinced that they are palatable. Additionally, the results suggest that price reduction would motivate the consumers to buy suboptimal bananas. Retailers may be well advised to rethink their policy of excluding suboptimal foods, because a proportion of consumers will be willing to buy them. From the home situation perspective the main contribution of this study is that consumers need to learn to smell and taste the food before discarding it to decrease the level of household food waste. However, the results also show that consumers are not familiar to use bananas for cooking, baking, and dessert preparation. Therefore, the study suggests providing basic knowledge for influencing consumer practices to use leftovers or too long ripened fruits in the kitchen. The results strongly support the approach targeting both, the consumer behavior in the supermarket and at home.

A limitation of the present study is that we used unpriced products so that the purchase intention score may be a poor indicator of actual purchase behavior. On the other hand, bananas are a familiar every-day food and in this sense most people have at least some idea of their normal price. As this study was conducted using a student sample, it should be extended to a representative sample, and the trade-off between food appearance and price should also

be considered. The attitudes towards food waste and sustainability, as well as information on purchase behavior was self-reported, so that it cannot be ruled out that participants gave socially desirable answers. Although this study collected a number of factors that may influence the intention not to waste food, consumers do not necessarily translate their intentions into behavior, what is referred to as intention-behavior gap (Carrigan & Attalla, 2001; Moser, 2015). On the one hand, future research should focus on investigating the factors that influence food waste behavior particularly in the case of suboptimal foods. On the other hand, more research is needed on the impact of purchase intention for suboptimal foods on real purchase behavior, and replicate the present study across other types of food and possible visual defects.

As the general public is to a great extent concerned about environmental and social consequences of food waste, it is of high interest to find ways to reduce food waste along the food supply chain with a main focus on households. To reach this target, marketing campaigns and private initiatives are employed attempting to raise consumer awareness about the issue as well as providing helpful guidelines supporting consumers to reduce waste. The results of this study provide insights into the role of sensory expectation and perception as determinants of consumer food choice and the potential to avoid food waste when making use of human senses. Convincing consumers that food is still palatable, despite a suboptimal appearance, is an important step in reducing food waste.

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Conflict of interest

The authors have no relevant interests to declare.

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Web Appendix

Appendix A. Development of sensory descriptors

In the two-alternative forced choice (2-AFC) tests (ISO, 2005) ten descriptors from literature, namely grassy flavor, banana flavor, sweetness, sourness, firmness, melting, heterogeneity, astringency, mealiness, and adhesiveness, were tested (Bianchi et al., 2016; Blaker, Plotto, Baldwin, & Olmstead, 2014; Bugaud et al., 2011; Nobile et al., 2011). The participants received a pair of half, crosswise cut, peeled bananas (RD 5 and RD 7) on white plates, encoded with random three-digit numbers, and an A5 sheet with the descriptors and checkboxes. They were asked to mark the sample for which the respective descriptor was more intense. Water was provided for mouth rinsing.

The attributes grassy flavor and firmness were rated as significantly more intense in the RD 5 banana ($p < 0.01$). Banana flavor, sweetness, sourness, melting, and mealiness were rated as significantly more intense in the RD 7 banana ($p < 0.01$). Based on Bugaud et al. (2013) who observed a significant negative correlation between firmness and melting ($r = -0.83$), and between sweetness and sourness ($r = -0.86$), melting and sourness were eliminated from the attribute pool. The restriction to a few specific attributes aimed at avoiding mental overload for participants in the main experiment. Five attributes remained for the main study.

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Appendix B: Analytical validation of banana ripeness

Methods

In the preliminary experiments, banana color, firmness of peel and flesh, and sugar content were, starting with RD 3, measured over 10 d to evaluate ripening progress. During the main study, the results for bananas of RD 5 and RD 7 were compared with the results of the bananas used for overall liking and attribute rating. RD 5 represents the ripening status that consumers will usually find in retail outlets, and bananas of RD 7 represent the suboptimal counterpart that is usually removed from the shelf.

Analytical color measurements were performed with a LUCI 100 (Dr. Bruno Lange GmbH, Berlin, Germany) spectral reflectometer using xenon D65 illumination and the 10° observer. Because of the lack of peel uniformity especially at RD 7 a set of ten measurements was performed along the arched back of two bananas from the stalk to the flowering. In the CIE-Lab system, L* refers to sample lightness, and chroma (C*) and hue (hab), calculated from the a* and b* coordinates, refer to saturation and color quality, respectively (Rohm & Jaros, 1996; Salvador et al., 2007).

Firmness of unpeeled and peeled bananas was measured using a TA-XTplus texture analyzer (Stable Micro Systems Ltd., Surrey, UK) equipped with a 5 kg load cell. The banana was placed on the sample support table with the curvature pointing towards the investigator, and penetrated with a cylindrical probe (diameter, 6 mm) that was mounted on the cross-head of the instrument. Cross-head speed was set to 1 mm/s, and penetration depth to 15 mm (unpeeled) or 10 mm (peeled sample). At each time of analysis, two bananas were measured in triplicate. Firmness is given as the arithmetic mean of the maximum force during penetration (Tapre & Jain, 2012).

Ten g banana flesh was mechanically blended with 100 g demineralized water for 1 min using a Multiquick Minipimer (Braun GmbH, Kronberg, DE), and subsequently filtered (Soltani, Alimardani, & Omid, 2010). 3 - 4 drops filtrate were placed on the measuring prism of an ATR table refractometer (Schmidt + Haensch GmbH & Co., Berlin, Germany) to measure the amount of soluble solids in °Bx (Liew & Lau, 2012; Soltani et al., 2010). Again, each of the two bananas was measured in triplicate.

Results

In the preliminary experiments it was found that L^* of banana peels increased significantly until RD 6, which was reached after 5 d storage at 20 °C, and then further decreased when brown spots started to develop. C^* varied similarly, indicating an increase in color saturation in the first stage of ripening. Due to the change from greenish-yellow to yellow-orange, banana peel hue changed from approximately 100° to 80°. These changes can be attributed to the breakdown of chlorophyll in the banana peel tissue, and to the development of xanthophyll and carotenes (Gomes et al., 2013; Soltani et al., 2010). As regards the main study, the peel hue of bananas with RD 5 and RD 7 differed significantly (Table B1).

Table B1. Sugar content, color and firmness of bananas of ripeness degree (RD) 5 and RD 7.

| Parameter | RD 5* | RD 7 |
|-----------------------|-------------------------|-------------------------|
| Peel hue h_{ab} (°) | 87.9 ± 3.7 ^a | 80.2 ± 2.5 ^b |
| Firmness unpeeled (N) | 28.7 ± 3.2 ^a | 11.2 ± 2.3 ^b |
| Firmness peeled (N) | 3.1 ± 0.3 ^a | 2.5 ± 0.3 ^b |
| Sugar content (°Bx) | 14.3 ± 1.7 ^a | 19.7 ± 1.4 ^b |

* Mean values in a row with different superscripts differ significantly ($p < 0.05$).

The firmness of both unpeeled and peeled bananas, which is an important property to be considered while evaluating eating quality (Jaiswal et al., 2012; Salvador et al., 2007), significantly decreased during ripening from RD 3 to RD 7 during the preliminary experiments in both, banana peel (from 61.2 ± 4.9 N to 12.5 ± 1.0 N) and flesh (from 6.2 ± 0.7 N to 3.0 ± 0.1 N). This softening is associated with the alteration in cell wall structure by pectin degrading enzymes (unpeeled), and the movement of water from peel to flesh and the conversion of starch to sugar (peeled) (Tapre & Jain, 2012). The maximum force needed to penetrate the peel and the flesh of RD 5 and RD 7 bananas used in the main study differed significantly (Table B1). This difference is in accordance with the results of the initial 2-AFC tests where firmness was also judged as being significantly different with RD 5 banana being firmer.

The content of the soluble solids increased continuously during ripening until a maximum of approximately 19 °Bx was obtained at RD 7 after 7 d storage. This is in accordance with other studies, showing sugar contents of full-ripened bananas of up to 20 °Bx (Liew & Lau, 2012; Salvador et al., 2007; Soltani et al., 2010). Bananas of RD 5 and RD 7 of the main study differed significantly in their sugar content (Table B1), which is also in line with the results of the initial 2-AFC tests, showing significant sweetness differences with RD 7 banana being sweeter.

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Erklärung zum selbstständigen Verfassen der Arbeit

Ich erkläre hiermit, dass ich meine Doktorarbeit „Consumption decisions in the food sector – Conceptual and empirical studies from the food marketing context“ selbstständig und ohne fremde Hilfe angefertigt habe und dass ich als Koautor maßgeblich zu den weiteren Fachartikeln beigetragen habe. Alle von anderen Autoren wörtlich übernommenen Stellen, wie auch die sich an die Gedanken anderer Autoren eng anlehrenden Ausführungen der aufgeführten Beiträge wurden besonders gekennzeichnet und die Quellen nach den mir angegebenen Richtlinien zitiert.

23.10.2017

Claudia Symmank